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UNIVERSITY OF ALBERTA

BIOGEOGRAPHY OF BIRDS IN THREE RESIDENTIAL COMMUNITIES IN EDMONTON, ALBERTA

BY

Douglas R. Edgar ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE.

DEPARTMENT OF GEOGRAPHY

Edmonton, Alberta
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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled THE BIOGEOGRAPHY OF BIRDS IN THREE RESIDENTIAL COMMUNITIES IN EDMONTON, ALBERTA submitted by D. R. Edgar in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE.

G.P. Kershaw.

G. P. Kershaw

D. B. Johnson

G. L. Holroyd

Abstract

In a one year period, the habitat and bird populations were studied in three urban residential communities in Edmonton, Alberta. The communities were approximately 35, 20, and 10 years old. An inventory of the tree cover showed that the types of trees planted by urban residents over the past 35 years has not changed significantly and a gradient was defined based upon the heights of the trees in each area. In all seasons the number of birds in each of the study areas was proportional to the number of coniferous trees greater than 6m in height.

The population density, number of species, and evenness of distribution declined from the oldest to youngest study area. The only bird species common to all three study areas throughout the study period was the House Sparrow.

Except in the winter season, the number of species and population density of birds was less in the urban areas than was determined in a number of wildland studies. These parameters were also less than was found in a number of other urban bird studies. As in most other urban areas, the House Sparrow was the most common species in all the study areas, comprising between 70% and 100% of the total bird population.

During the breeding and post-breeding seasons it was found that American Robins and Chipping Sparrows preferred different types of habitat. The relative abundance of these species was correlated to variables within the tree cover. Both species were found to occur at breeding densities higher

than was found in some wildland studies. A number of species showed a preference for specific types of trees within the urban habitat. These include the Savannah Sparrow which fed on sawfly larvae common in birch trees during the post-breeding season, while in the winter season, waxwings showed a preference for Mountain Ash and crabapple trees, and redpolls were associated with mature birch trees.

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1.1 Introduction

Since World War II, the urban population in Canada has grown from 55% in 1941 (Statistics Canada 1941) to 75.7% in 1981 (Statistics Canada 1981). Edmonton, over the same period, grew from 92,406 in 1941 to over 750,000 in 1986 (Canada Yearbook 1986). Urban centres, such as Edmonton, have grown to become significant geographic features on the prairie landscape, yet, the scientific literature contains virtually no data regarding the biogeography of urban birds inhabiting these areas of western Canada and central Alberta in particular.

Beginning in the 1970's a growing scientific interest in urban wildlife and urban ecology resulted in a number of studies in other countries and although there are more differences than similarities to the urban environment in Edmonton these studies have some general application. Batten (1972) used historical records to reconstruct the effect of urbanization upon the bird species diversity at Brent Reservoir near London, England. He found that as the degree of urbanization increased, the bird species diversity decreased. The majority of these studies have found that the urban environment is dominated by exotic birds such as House Sparrows and Starlings. This was found to be true of such diverse sites as Tuscon, Arizona (Emlen 1974) and Canberra, Australia (Lenz 1990). Emlen, who compared an urban area with a desert site, found that the urban area supported a greater number of individual birds, but the bird species diversity was less in the urban area. In the Canberra study, it was found that the retention of native trees led to a greater dominance by exotic bird species.

In the Netherlands, Van der Zande et al (1984) found that recreation intensity, measured using the number of people present in a wooded park, had a negative impact on the distribution of 8 of 13 bird species. Although these studies have been conducted in geographic regions with different climatic regimes and different assemblages of birds, the results are, in a general manner, applicable to the urban environment of Edmonton.

An increasing awareness of the uniqueness of the urban environment for avifauna led to a number of urban bird studies being conducted in eastern Canada. Studies by Erskine (1970) estimated breeding bird densities in Senneterre, Quebec at 218 birds km^{-2}. Speirs et al. (1970) estimated the breeding bird population on 10 urban plots throughout southern Ontario at between 1,344 and 2,637 birds km^{-2}. During the winters of 1969 to 1971, Erskine (1974) estimated the winter bird population in Ottawa to range between 4 and 472 birds km^{-2}. In 1974, Savard (1978) studied the birds in a number of Toronto neighbourhoods and found the bird density ranged between 204 and 1876 birds km^{-2}. The numbers varied with the season and the area being sampled. Savard also found a positive correlation between their distribution and the volume of the canopy at various heights. Weber (1975) studied 185 nests of 10 bird species in Vancouver and found that urban birds seldom nested below 3m. Campbell and Dagg (1976) found the diversity of wintering and breeding birds in Kitchener-Waterloo was lower near the city centre and increased toward the suburbs. They also found a higher population density in urban areas when compared with rural sites. In addition to field studies, Dagg (1970) conducted a survey of 1421 households in Waterloo, Ontario to assess the identification ability and perceived desirability of urban wildlife. While the results of these studies are of general interest, differences in climatic regimes, the extent of urbanization, the physiognomy of the forest cover, and in the assemblage of avifauna all limit the application of these studies to the urban environment of Edmonton.

In western Canada, very few urban bird studies have been undertaken. Erskine (1972) conducted a breeding bird survey at Swan River, Manitoba (population 3500). In that study, it was found that House Sparrows, American Robins, and Chipping Sparrows comprised 87% of the breeding bird population. Oliphant and MacTaggart (1977) studied the prey taken by urban Merlins in Saskatoon, Saskatchewan. Spencer (1973) inventoried the wildlife in four Edmonton ravines during the winter of 1972/1973. This study also included a perception study which assessed the attitudes of some urbanites towards urban wildlands and urban wildlife. These studies are of interest since they involved species found within Edmonton and they were conducted in geographic areas which were similar to those found in urban Edmonton. As a consequence, their findings should be directly applicable to the avifauna habitat of Edmonton.

In Edmonton, a number of species specific studies have been conducted. These include Reebs and Boag (1987) who identified communal roosting sites of Black-billed Magpies within the Edmonton river valley system and studied the behaviour of magpies at these roosting sites. Manjit and Boag (1989) found that supplementary feeding increased the survival rate of both eggs and young. It also increased the fledging success of the juvenile birds. Manjit, Komers, and Boag, (1989) reported on dominance relationships between juvenile and adult magpies at artificial feeding sites. They found that adult males most often deferred to juvenile males and surmised that this was related to the greater foraging success of the males. James and Smith (1987) found that House Sparrows comprised 75% of the prey taken by urban Merlins in Edmonton and Fort Saskatchewan. Each of these studies elucidate some behaviourial aspect of birds found in urban Edmonton.

It is evident from a survey of the literature that there are 2 problems that have a significant impact on a study of the avifauna of Edmonton.

1. there are few studies of urban avifauna
2. most studies that are available have been conducted in habitat very different from that of Edmonton

As a consequence, a study of Edmonton's avifauna would be largely without precedent and therefore become the foundation for further, more detailed research.

1.2 Research Objectives

The population size of an avian community is limited by four factors; disease, climate, habitat, and food availability (Gill 1989). The latter two factors are considered, by that author, to be the most important. These factors have been largely ignored in the urban context and the results of several workers, such as Erskine (1972) and Flack (1976), suggest that the results of non-urban studies are of extremely limited value in an urban setting.

In terms of species composition differences between rural and urban habitats Erskine (1972) found that House Sparrows, Chipping Sparrows, and robins accounted for the majority of the breeding bird population (87%) in Swan River, Manitoba. Flack (1976) did not sight House Sparrows or Chipping Sparrows in his study of breeding birds in three wildland sites in central Alberta and robins accounted for only 7% of the breeding population. It is apparent from these and other studies, (Savard 1978, Campbell and Dagg 1976, Weber 1975, Yahner 1986, Niemi and Hanowski 1984, and Bock and Lynch 1970) that there must be gross differences in habitat and resource availability. As a consequence of these differences, it is difficult and possibly misleading to draw parallels between urban and natural avifauna habitat without qualifications.

Some studies of urban birds have been conducted in Edmonton. However, temporal and spatial relationships have not been addressed. It was in an effort to address this information gap that the following investigation was initiated. To this end, a number of research objectives were identified:

- determine the density, diversity, and composition of the bird population in three study areas during the breeding season, post-breeding season, and winter season.

- determine the characteristics of a major habitat variable, the composition and height characteristics of the tree cover in the study areas.

- determine the size and density of breeding territories held by strongly territorial species.

- identify relationships between habitat features and birds in the study areas.

- Compare the findings in this study with the results of other urban and non-urban studies.

The first part of this report describes the diversity and density of urban birds in three urban residential communities during the breeding season, the post-breeding season, and winter seasons. The second section describes the structure of the tree cover in the three study areas and its impact on the distribution and diversity of birds in the three seasons.

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2. The biogeography of birds in three residential communities in Edmonton, Alberta

2.1 Introduction

Urban bird populations of the breeding season have been studied more intensely than the bird population at any other season. In eastern Canada, these include studies in Quebec (Erskine 1970), and Ontario (Speirs et al 1970, Campbell and Dagg 1976, and Savard 1978). In western Canada, research has been conducted in Manitoba by Erskine (1972) and in British Columbia by Weber (1975). Each of these studies resulted in an inventory of the birds breeding in urban environments.

In addition some of these studies related bird abundance to habitat features. Weber investigated habitat features selected as nest-sites. Savard found a positive correlation between the volume of the canopy and the density and diversity of breeding birds. Speirs found an inverse relationship between the degree of commercialization and the density and diversity of the breeding birds. Each of these authors found that exotic species, such as House Sparrows, dominate the urban breeding bird populations and comprise up to 70% of breeding urban birds. These results are similar to results found by other researchers, such as Emlen (1974) in Tuscon, Arizona (65%) and Lenz (1990) in Canberra, Australia (63%).

Few studies on birds of the post-breeding season have been published and those, such as Erskine (1968), tend to be little more than lists of birds sighted. An exception to this circumstance is Savard's (1978) study of birds which employed a strip census method to inventory the species present in a number of urban Toronto neighbourhoods during the post-breeding season and related the bird population to the volume of the canopy. As a consequence of the lack of published data, there is little information against which to compare patterns of dispersal and distribution of urban birds in Edmonton.

Since 1900, North American birdwatchers have conducted annual Christmas Bird Counts (CBC) to census bird populations across the continent (Root, 1988). Though these counts almost certainly represent the largest body of data available on the distribution of North American birds in winter, their application on a local basis is limited since the results are pooled. Until recently, in Edmonton, bird watchers have devoted the majority of their efforts in the ravines, parks, and river valley which support a more diverse bird population than the residential areas (Spencer 1973). As a consequence, results in data from residential areas have been under-represented in the summaries. Based upon the authors experience, this is certainly true of the CBC zone which includes the Parkview Study area. Beyond the Christmas Bird Counts, over-wintering birds in the urban environment are poorly documented in the literature. Erskine (1974) sampled over-wintering birds on 10 sites in Ottawa, Ontario and found that the population density was 472 birds/km^2. Ottawa has a mean January temperature of -10.9°C and receives 61mm of snow (Crowe 1984). Savard's (1978) study of birds in urban Toronto included sampling winter bird populations. Savard found that population densities ranged from 204 to 1942 birds km^{-2} and that these populations were dominated by exotic bird species. The mean January temperature for Toronto is -4.7°C and the normal precipitation is 60.9mm (Auld et al 1990). The above studies were conducted in areas with less extreme winter climates than that of Edmonton which has a mean January temperature of -15°C and 24.6mm of precipitation (Table 2.1). This coupled with differences in the composition of the avifaunal assemblage make comparisons with the Edmonton environment problematic.

The objective of this study is to describe the density and diversity of the breeding, post-breeding, and winter bird populations in three urban residential communities of different ages in Edmonton, Alberta. In addition, this study describes some relationships between habitat development and bird density and diversity.

2.2 Study Areas

Edmonton (53° 30' N, 113° 30' W), with a population in excess of 750,000, and occupying an area of 67,000 ha is the most northerly major urban centre on the North American continent. Edmonton is located in the Aspen Parkland region of north-central Alberta which is an ecotone forming the transition between the Grasslands and Boreal forest biomes (Wilkinson 1990).

The climate is typical of a mid-latitude continental location with 4 seasons. Two of these seasons, summer and winter, have relatively stable temperature regimes (Table 1.1). Summer begins in mid-May and lasts until early September, while winter begins in mid-November and lasts until mid-March. The transitional seasons are relatively short and they are characterized by daily temperatures similar to either winter or summer. Edmonton has an average precipitation of 466.1mm and an average 120 frost-free days (Olsen 1985).

Three study areas were selected in west Edmonton (Figure 2.1) as being representative of different degrees of residential development (e.g. size and diversity) in the tree cover, along a gradient from near the city centre to the urban fringe. The areas of Parkview (Figure 2.2), Thorncliffe (Figure 2.3), and Laperle (Figure 2.4) are typical of residential suburbs 35, 20, and 10 years old, respectively. Each of the study areas are free of extensive re-development and they are structurally similar (Table 2.2), with similar lengths of roads and parks size. Each of the study areas contain only single family dwellings.

The Parkview and Thorncliffe study areas were similar in shape and consequently the relative length of the edges to the enclosed area were also similar (Table 2.2). This parameter is indicative of the shape of an area. A square area will have the least amount of edge while an elongate area will have a high edge length per unit area. The LaPerle study area was more elongate than the other areas and, as a result, had a somewhat larger perimeter to area ratio. While this disparity in shape was less than desirable, it was balanced by the equal access to the rear of the properties. Many of the newer residential areas in Edmonton lack laneways and this limitation in access could affect survey efficiency. LaPerle was selected since most of the study area had laneway access and thus the area could be as uniformly covered by an observer, as Parkview and Thorncliffe both of which have access to the rear of properties.

The Parkview study area was surrounded by residential developments as were the other study areas. However, Parkview was bounded on the east by a major thoroughfare, 142 St., beyond which was another residential area. Residential properties also continued to the south and west of the study area. A schoolyard, apartment building, and a small commercial development bounded the northern edge of the study area.

The Thorncliffe study area was also located within a more or less continuous residential area but was bounded on the east and south by major thoroughfares. The thoroughfare along the southern margin was separated from the study area by a berm and a noise reduction wall. Residential housing extended approximately 0.5 km north of the study area. Beyond the western margin lay further residential housing and a small shopping centre.

The LaPerle study area was located on the urban fringe. Beyond the northern and western margins lay undeveloped rural land. Similar residential housing extended to the south and east of the study area.

There were differences in the characteristics among the 3 study areas. However, given the complexity of the urban environment, the 3 areas had as many characteristics in common as possible while dealing with subdivisions constructed at different times during the history of Edmonton's urbanization.

2.3 Methods

The distribution and density of birds within the three study areas were determined using a belt transect mapping method (Mikol 1980) similar to that employed by Emlen (1974) and Savard (1978). In the breeding season this method was used to determine the distribution and density of non-territorial and weakly territorial birds. This technique involved a single observer moving at a more or less constant speed of 3 km h^{-1} along a fixed route. The location of all birds, from the centre of the transect belt to the roofline of the nearest dwelling on each side (approximately 25m), were recorded on a 1:5000 cadastral map together with the habitat feature being used and the activity at the time of observation. To be included in the dataset, an individual bird had to alight within the transect area. Overflying species which had no real association with the study area were not included in the mapping analysis. Counts were not conducted during periods of precipitation or when the winds exceeded 20km h^{-1} and all counts were completed before 1000h (the average time/count = 1.5hrs).

Breeding territorial birds were mapped using the William's Spot Mapping method (Hall, 1964), again, recording locations and habitat features being utilized on a 1:5000 cadastral map. Care was taken to include only singing males. Data from the spot counts were compiled on a separate map for each species in order to determine the size and number of territories within the three study areas. Territorial boundaries were determined by linking observed singing posts. In the oldest study area, Parkview, singing male birds were mapped on 16 occasions (15, 21 April; 4, 9, 11, 13, 16, 20, 30 May; 9, 19, 23, 25, 28 June; 18, 23 July). A total of 6 spot counts were conducted during the same period (5, 12, 18, 21 May; 3 June; 24 July), in the younger Thorncliffe study area. In LaPerle, the youngest study area, 5 spot counts were conducted (10, 12, 18, 27 May; 9 June). During the spring of 1991, 12 spot counts were conducted in the Parkview study using the same methods (15, 16, 17, 20, 21, 29 April; 14, 19, 20, 23, 26 May; 6 June).

Defining the "seasons" for urban birds is a somewhat subjective process since different species breed at different times of the year. Generally, permanent residents tend to breed earlier than seasonal migrants. It has long been known that overwintering birds begin effecting breeding behaviour soon after the winter solstice (Rowan in Gill, 1990), yet, nesting does not immediately follow the onset of these behaviours for most species. Casual observation, in previous years (1988 and 1989), suggested that the number of species present was at its lowest in early April, since at that time, overwintering species had departed and summer species had not yet arrived in the area. These past observations were used to define the sample period. With these constraints in mind, the breeding season was defined as beginning when the first singing Robins were heard on 13 April 1990. As a result, week 1 of the study period was defined as beginning 14 April and it was considered to have ended by week 15 (28 July 1990) when obvious breeding behaviour was no longer observed in the bird population. The beginning of the post-breeding season was contiguous with the end of the breeding season and lasted until the first major snowfall. The winter season began with the first major snowfall (11 November) and lasted until the first singing male robin was sighted on 2 April 1991.

The average number of birds per hectare and the proportion of each species counted over the field season were calculated along with the Shannon-Weaver Index, H', of bird species diversity (MacArthur and MacArthur, 1961). The index was calculated where:

$$H' = -\Sigma^{n} Pi\ Ln(Pi) \qquad [1]$$

Where:

H' = Shannon-Weaver Index of Diversity

Pi = proportion of the total population in the i th species.

$Ln(Pi)$ = Natural Logarithm of Pi.

The Kruskal-Wallis H-test (Campbell 1989) was used to test for significant differences when more than 2 samples were analyzed. The H-test used the following relationships:

$$H = 12/n(n+1) * (T1^2/n1 + T2^2/n2 + T3^2/n3) - 3(n+1) \qquad [2]$$

Where:

$n1, n2, n3$ = number of replicates in the samples.

$n = n1+n2+n3$

$T1, T2, T3$ = rank sum of the samples.

To measure the dispersion in non-territorial birds, computer software was written to execute a nearest-neighbour analysis of spatial distribution. This algorithm compares the actual distance between points with a calculated expected distance. The ratio of the two distance values is known as an R-value. An R value less than 1.0 indicates clustering while R values greater than 1.0 indicates dispersal within the bird population.

2.4 Results

2.4.1 Number of Surveys

It was felt that the small number of surveys in the youngest study area, LaPerle, might have affected the results. To test the hypothesis that the total number of birds counted could be affected by a small number of surveys, a statistical experiment was constructed. In the Parkview area where 30 surveys were made during the one-year study period, a small sample comprised of every third replicate (10) was extracted from the dataset. A Chi-square distribution was used to determine the 95% confidence limits for the variance of the large sample. The confidence limits were determined to be 303 to 2136 (df=9, $\alpha/2=.024$, $1-\alpha/2=0.975$). The variance for the small sample was calculated as 640.9, which was within the confidence limits of the large dataset. On this basis, the hypothesis was accepted and it was concluded that a small number of surveys did significantly affect the total number of birds counted.

2.4.2 Breeding Season

2.4.2.1 Bird Censuses

A total of 6 surveys were conducted in Parkview (6, 13, 20 May, 9, June, 7, 23 July), 4 surveys in Thorncliffe (5, 21 May, 3 June, 24 July), and 3 surveys in LaPerle (12, 18, 27 May). The average number of birds counted in the mature Parkview study area was 99.3 while in the younger Thorncliffe area an average of 54 birds was counted. In the most recently developed subdivision, LaPerle, an average of 7.67 individuals were counted. These represent respective population densities of 497, 257, and 33 birds km^{-2}.

The Shannon-Weaver Index of Species Diversity (MacArthur and MacArthur, 1961), which is a relative measure of the evenness in distribution of the individuals counted between the species present, was used as a measure for comparing the species diversity in the three study areas. In Parkview the average diversity was 1.269 while in the Thorncliffe area the average diversity was 0.909. Since only a single species was observed in the LaPerle area, the diversity was 0.00. The oldest subdivision, Parkview contained a larger average number of birds and the Shannon-Weaver Index indicates that these individuals were more evenly distributed among the number of species present.

A total of 10 bird species were seen in Parkview, 6 species in Thorncliffe, and 1 species in the Laperle area.

2.4.2.2 House Sparrow

The House Sparrow (Passer domesticus) was the most numerous species within all three study areas (Table 2.3). Observations were not conducted during the 1990 winter season, however, the following winter male House Sparrows were observed singing and displaying on 31 January 1991. By 19 March 1991 (week 52), 15 pairs could be discerned at known breeding sites. In week 3 of the study period, 4 May 1990, 14 pairs were observed in association with nesting sites. The discrepancy between the total number of House Sparrows and the number of apparent breeding pairs, suggests that some birds were non-breeders or that some birds were not recognized as breeders. Much the same behaviour pattern was apparent in the younger Thorncliffe study area where six pairs were associated with apparent nesting sites by 9 March 1991. The numbers of House Sparrows in the youngest of the study areas, LaPerle, were too low to discern patterns of dispersal. Murphy (1978) found that House Sparrows, near Calgary, had a median clutch initiation date of 15 May 1975 and 1 May 1976 and also found that the breeding season started later and was shorter for House Sparrow populations at higher latitudes.

The House Sparrows appeared to be dispersed throughout the study areas during the breeding season, this was especially noticeable in the Parkview study area (Figure 2.5). A nearest neighbour analysis of all House Sparrows recorded in the Parkview study area between 14 April and 23 July yielded an R value of 0.94. However, the calculated value indicates that the birds were weakly clustered.

The results of the complete counts indicate that the two younger study areas supported fewer House Sparrows than the older Parkview area. To test the hypothesis that the same number of House Sparrows were counted in the three study areas, a Kruskal-Wallis Analysis of Variance of Rank was performed on the data. From this test, it was determined that the H statistic (25.875) was more than the critical Chi-square value (5.99 when α=.05 for 2 degrees of freedom). Therefore, the null hypothesis was rejected and it was concluded that there were statistically significant differences in the number of House Sparrows counted in the three study areas.

To test the hypothesis that the number of House Sparrows in the three study areas was correlated to the number of trees greater than 6m in height (Edgar 1992, Part 3), a Spearman Rank Correlation test (Sincich 1985) was employed. The resultant rs of 1.0 indicated a perfect correlation between the variables. As a consequence, the null hypothesis was accepted and it was concluded that the number of House Sparrows was related to the number of trees greater than 6m in height.

The House Sparrows are among the most adaptable of the breeding birds found within the urban environment (Werler and Franks, 1975) and, as previously stated, they had acquired nesting sites by mid-March. The sites selected for nesting include single bird houses, multiple-nest bird houses, and, in Parkview, lamp standards. The lamp standards used in Parkview consist of a straight length of thick-walled pipe to which a lamp support is clamped. This type of lamp standard has a hole near the distal end which provides a means for connecting the wiring to the lamp proper. This hole provides access to the interior of the supporting pipe and the result is very much like a nesting cavity in a tree. The older study area contained 20 of this type of lamp standard and 17 (85%) of these were used as nesting sites by House Sparrows. Lamp standards in the younger Thorncliffe and LaPerle study areas are of a different design and do not offer openings which might provide access to nesting House Sparrows.

In the oldest study area, Parkview, breeding House Sparrows had no apparent hesitation in using birdhouses with multiple nest cavities which were intended for colonial birds such as Purple Martins (100% of 9 multiple cavity birdhouses showed evidence of breeding House Sparrows). Birdhouses designed for single pairs of nesting birds were used exclusively by House Sparrows (100% of 14 single cavity nesting sites). In the Thorncliffe study area, artificial nesting sites appeared to be used exclusively by House Sparrows. In the LaPerle study area, the low density of birds left birdhouses unused.

By 23 July 1990, House Sparrows in the older Parkview area had begun congregating in localized areas and this was interpreted to indicate the formation of flocks. On the map of breeding season sparrow distribution, the groups of greater than 5 formed late in the breeding season (late July). In the younger Thorncliffe area, flocking in House Sparrows was apparent by 24 July 1990. This behaviour was considered to mark the end of the breeding season for this species. It appeared that the House Sparrows in LaPerle, the youngest of the study areas, belonged to a single flock, however, due to the low numbers flocking was not measurable in any quantitative manner.

2.4.2.3 American Robin

The first singing male American Robin (Turdus migratorius), considered by many urban dwellers to be the true harbinger of spring, was heard in the Parkview study area on 13 April 1990. This was two weeks after the first individual was sighted in the Parkview subdivision (30 March 1990). The following spring, the first male robin was seen on 2 April 1991 and the first singing male was heard on 9 April 1991. In both seasons, male robins were apparent in the area from one to two weeks prior to the onset of obvious territorial breeding behaviour, such as singing and displaying. The time lag between first appearance and the onset of breeding behaviour may be a response to the rigours of migration.

In the spring of 1990, 15 complete territories were being defended by singing male robins in the Parkview study area

(Figure 2.6). These territories ranged from 0.566 ha to 1.523 ha and averaged 0.760 ha (standard deviation: 0.273). In addition to the complete territories, 5 partial territories were identified for a total of 17.5 pairs or a breeding density of 87.5 pairs of robins per km^2. During the 1991 breeding season 9 complete territories and 6 partial territories were being actively defended (Figure 2.7). The complete territories ranged from 0.716 ha to 1.144 ha with a mean area of 0.899 ha (standard deviation: 0.132). This represented a breeding population of 60 pairs of breeding robins per km^2. The average area for the territories in 1990 and 1991 was 0.83 ha.

A 15x2 contingency table was used to test the hypothesis that the number of coniferous trees and the number of birch trees greater than 6m in height (Edgar 1992, Part 3) was the same for each of the Parkview breeding territories. The results indicate that the calculated Chi-square (32.15) was greater than the critical value (23.68, df=14, α=0.05). Thus the null hypothesis was rejected and it was concluded that the number of coniferous and birch trees, greater than 6m in height, varied significantly between territories.

In the Thorncliffe study area, 4 American Robin territories were identified (Figure 2.8). These territories ranged from 0.958 ha to 1.238 ha in area with a mean area of 1.07 ha (standard deviation: 0.399). Breeding density was therefore 19.05 breeding pairs km^{-2}.

A Kruskal-Wallis H-test was used to test the hypothesis that, during the 1990 breeding season, the area of breeding territories in Parkview were the same size as the territories in Thorncliffe. The calculated H-statistic of 6.76 was more than the critical Chi-square of 3.84 (df=1, α=0.05). Based upon these results, the null hypothesis was rejected and it was concluded that the area of the breeding territories in the two study areas were significantly different.

Fewer robins were counted in the Thorncliffe study than in the older Parkview study area. To test the hypothesis that the number of robins counted in the Parkview study area were the same as the number of robins counted in the younger Thorncliffe study area, a Kruskal-Wallis H-test was applied to the data. It was determined that H statistic (3.68) was less than the critical Chi-square (3.84, df=1, α=0.05). Based upon these results, the null hypothesis was accepted and it was concluded that the number of robins counted in the Parkview study area was not significantly different from the number of robins counted in the Thorncliffe study area.

One of the prime factors in delineating breeding territories appeared to be the availability of singing posts. Generally, it was found that singing male robins favoured the highest available exposed sites as singing posts. This was apparent in their choice of singing sites within the Parkview study area, 62% of the sightings of singing male robins were in the crowns of conifers (Table 2.4) which all were in excess of 6m in height. Such trees provide, by virtue of their height and shape, a singing post which is conspicuous to neighbouring male robins. Yards in the area bounded by 144 St., 146 St., 91 Ave. and 90 Ave. of the Parkview study area contained fewer tall conifers and the robins were compelled to seek other singing sites. 22.5% of all robins used power lines which are strung at heights up to 9m. Overhead powerlines were strung in laneways in the older subdivision, while the newer developments were serviced by underground power cables. An additional 8.5% of the singing males were perched in birch trees in Parkview.

In the Thorncliffe area, which lacks tall conifers and overhead powerlines, the robins were compelled to use alternate sites as singing posts. Consequently, maple, birch and mayday trees were utilized to a much greater extent than in Parkview. While there were fewer high singing posts, there appeared to be no lack of trees capable of supporting a nest at heights between 2m and 6m (Edgar 1992, Part 3). These observations suggest that the availability of singing posts may be a factor related to the distribution of robins.

To test the hypothesis that singing male robins in both study areas showed an equal preference for coniferous and birch trees (Edgar 1992, Part 3) as singing posts, a 2x2 contingency analysis was used. The resulting Chi-square value of 22.4 was greater than the critical Chi-square of 3.84 (df=1, $\alpha=0.05$). As a result, the null hypothesis was rejected and it was concluded singing male robins in the two study areas did not show an equal preference for coniferous and birch trees.

To test the hypothesis that the number of breeding robins in the Thorncliffe and Parkview study areas was not correlated to the number of trees in excess of 6m (Edgar 1992, Part 3), a Spearman Rank Correlation test was employed. The analysis resulted in an r_s of 1.0 indicating that there was a correlation between the variables. Consequently, the null hypothesis was rejected and it was concluded that the number of robins breeding in Thorncliffe and Parkview was related to the proportion of trees in excess of 6m.

Ornithological field guides (Godfrey 1986 and Harrison 1984) state that nests for this species are usually located at a height between 1.5m and 7m. In Parkview 8 nest sites were identified during the 1990 season and 14 during the 1991 breeding season. In the Thorncliffe study area, two of four nest sites were located. The nests in the older area were most often located at heights between 3m and 6m. The two nests located in the younger area were located at approximately 2m. In the Parkview area, 4 nests from the 1990 season were located in Manitoba Maple trees and the remaining 5 were located in spruce trees. During the 1991 season, 2 of 8 first nests were located in Manitoba Maple and the balance were located in spruce trees. Four of the second nests were located (approximately 3m above ground) over 0.9km of boulevard along the eastern and northern margins of the study area. Two of these nests were located in small (5m) Manitoba Maple, two in 8m elm trees and two in spruce trees. In the Thorncliffe area, 1 nest from 1990 was located in a Manitoba Maple and the other in a spruce tree. Urban nesting robins therefore appear to situate their nests within the same height range as the literature suggests. Furthermore, urban populations site nest heights similar to wildland populations according to local conditions.

Typical breeding behaviour, such as singing, was absent in the robin population by the third week of July (18 July 1990 for Parkview and 24 July 1990 for Thorncliffe). The absence of such behaviours was considered to indicate the end of their breeding season. A decline in the number of American Robins was noted in the data collected in the last two weeks of July suggesting a dispersal of nesting robins and their young by that time.

2.4.2.4 Chipping Sparrow

Chipping Sparrows (Spizella passerina) were first observed in the older Parkview study area on 13 May 1990 and in the younger Thorncliffe study area on 12 May 1990. These arrival dates were consistent with observations in the Parkview area in 1989 (13 May) and 1991 (11 May). Males began singing upon arrival.

During the breeding season, fewer Chipping Sparrows were counted in the Thorncliffe study area than in the Parkview study area. To test the hypothesis that the number of Chipping Sparrows counted in Thorncliffe were different from the number counted in Parkview, a Kruskal-Wallis H-test was used. The results of the test indicate that the H-statistic of 1.089 was less than the critical Chi-square (3.84, df=1, α=0.05). Thus, the null hypothesis was rejected and it was concluded that there was no significant difference between the number of Chipping Sparrows counted in Thorncliffe and Parkview.

In the oldest study area, Parkview in 1990, 8 complete territories and 1 partial territory were identified (Figure 2.9) with areas ranging between 0.142 ha and 0.596 ha (average of 0.336 ha, standard deviation:0.151). In the 1991 breeding season, 8 complete territories were identified (Figure 2.10). The complete territories ranged from 0.204 to 0.611 ha in area with a mean of 0.406 ha (standard deviation: 0.159). The breeding densities were 42.5 and 40 pairs km^{-2} in the respective years. For both years, the mean area of the breeding territories was 0.371 ha (standard deviation: 0.0496).

In the younger Thorncliffe study area 5 complete territories and 1 partial territory were identified in the 1990 breeding season (Figure 2.11). These territories tended to be considerably larger than those in the older area ranging from 0.641 to 0.771 ha (average area of 0.696 ha, standard deviation: 0.0463). To test the hypothesis that breeding territories in Thorncliffe were the same size as the breeding territories in Parkview, a Kruskal-Wallis H-test was applied to the data. The calculated H statistic (8.57) was greater than the critical value of 3.84 (df=1, α=0.05). Based upon these results, the null hypothesis was rejected and it was concluded that the breeding territories in Thorncliffe were significantly different in area from than those mapped in Parkview. In Thorncliffe the breeding population was smaller with a breeding density of 26.2 pairs km^{-2}. The larger territories may be the result of less competition for breeding space in the younger study area or habitat quality differs resulting in different carrying capacities.

To test the hypothesis that the breeding density of Chipping Sparrows in the two study areas was correlated to the number of trees in the 6-9m height class (Edgar 1992, Part 3) a Spearman Rank Correlation test was used. The calculated r_s of 1.0 indicated a perfect correlation between variables. Consequently, the null hypothesis was accepted and it was concluded that the breeding density of Chipping Sparrows was proportional to the number of trees between 6 and 9m in height.

In the older study area, 44.4% of the Chipping Sparrows selected coniferous trees as singing posts (Table 2.5) and 18.5% utilized birch trees. In the medium aged Thorncliffe study area 31.2% of singing male Chipping Sparrows favoured coniferous trees as singing posts while 40.6% favoured birch trees. A 2x2 contingency table was used to test the hypothesis that singing male Chipping Sparrows in Thorncliffe and Parkview used conifers and birch equally as singing posts. It was determined that the Chi-square was 20.07 was greater than the critical Chi-square (3.84, df=1, α=0.05). Therefore the null hypothesis was rejected and it was concluded that singing males, in the two areas, did not use these trees equally as singing posts.

The nests of Chipping Sparrows are commonly sited between 1 and 6m above ground in conifers and shrubs (Harrison 1984). No nesting sites were located in either of the study areas.

2.4.2.5 Black-billed Magpie

Black-billed Magpies nested at a single site in each of the Parkview and Thorncliffe study areas. In the older Parkview area, the nest was located in a fork near the crown of a spruce tree. The nest site in the younger Thorncliffe area was situated in the forked branches of an elm tree. Both were approximately 6m above the ground and consisted of a more or less loose accumulation of small sticks. In Parkview, the magpies were first recorded at the nest site on 20 May 1990 although they had been observed in the area of the nest site on 22 April 1990. Normally clutches are initiated 39 to 46 days prior to fledging (Harrison 1984). By 18 July 1990, the nest site had been abandoned and the adults were observed within the study area together with several juveniles, suggesting that the nest was begun sometime in early April.

In the Thorncliffe area a pair of magpies was observed about the nest site on 5 May 1990 and the female was observed to be on the nest on 12 May 1990. Magpies were not observed at the nest site after this date, although they were recorded within the study area on a more or less regular basis until 14 December 1990. The nesting pair were never observed in the company of juveniles and the success rate of the nest is not known.

2.4.2.6 Blue Jay

Casual observation has shown the Blue Jay (Cyanocitta cristata) to be one of several species of secretive nesters encountered in the urban environment. A single adult was seen within the Parkview study accompanied by three juveniles on 28 May 1990. The relatively low abundance during the breeding season suggests that Blue Jays were nesting in or near the study area. Much the same circumstance was apparent in the 1991 breeding season, with three juveniles being observed in the company of an adult through most of June. During this period the young would often exhibit begging behaviour and an adult jay would feed the young. By mid-July the juveniles were still in the local area, but, they were not being fed by the adult birds. There was considerable anecdotal information regarding nesting Blue Jays near the Parkview study area. Blue Jays were not seen in either the Thorncliffe or LaPerle study areas.

2.4.2.7 Black-capped Chickadee

As with the Blue Jay, the Black-capped Chickadee was a secretive nester. There was, however, some anecdotal information for Black-capped Chickadees nesting in early April approximately 50m to the west of the Parkview study area (D. Vitt, pers. comm.). Chickadees were apparent in smaller numbers during the winter season and a marked increase was witnessed during the post-breeding season. While it is recognized that other behaviours may account for the seasonal differences in apparent abundance, one possibility is to attribute the increase in numbers to the breeding success during the 1990 season.

Black-Capped Chickadees were not seen in either of the younger Thorncliffe and LaPerle study areas.

2.4.2.8 Northern Merlin

Although the Northern Merlin (_Falco_ _columbiarus_) did not breed within any of the study areas, they have nested within 0.5 km of the Parkview study area in 1989, 1990, and 1991. The nest sites were located to the north, west, and east in respective years.

In the 1991 breeding season, these birds were observed on a consistent basis within the Parkview study area, though outside of the normal count times. The nest site was established in late March and the adults were first observed calling near the nest on 28 March. The adults were observed copulating on 6 April. This date is consistent with a breeding pair observed copulating on 3 April 1990, in the Glenora district which is approximately 3 km north of the Parkview site. Merlins were observed to be very quiet when on the nest, but, they become extremely vocal once the young are fledged. In the 1991 season, the Merlins became increasingly vocal in the first week of July and 2 juveniles in the company of the adults were observed on 10 July. Harrison (1984) gives a period of 53 to 62 days from clutch initiation to fledging. Field observations suggest the period from insemination of the female to sighting of fledged young was on the order of 98 days, however, the dates of clutch initiation and fledging are not known. Some birds are able to delay fertilization for extended periods (some domestic fowl up to 72 days) after insemination (Gill, 1990).

Juvenile Merlins were seen in the company of the adults on an almost daily basis from 10 July to 20 July. By 20 July, the nest site had been abandoned and the Merlins had dispersed.

2.4.2.9 Migrants

A number of migrating bird species were more or less common during this period. One of the earliest transients to appear was the Dark-eyed Junco (*Junco hyamelis*), which was recorded from 4 May 1990 to 13 May 1990. Three Yellow Warblers (*Dendroica petechia*) were observed singing on 20 May 1990. Swainsons Thrush (*Catharus ustulatus*) was observed on 13 May. In addition, a number of Yellow-rumped Warblers (*Dendroica coronata*) were observed on 5 May 1990 outside of the formal count period. Each of these species can be found nesting in the Edmonton region. None of the above transients were observed in the younger Thorncliffe and LaPerle study areas.

A number of overflying migrants were also seen in the skies over the city. These include Canada Geese (*Branta canadensis*), Sandhill Cranes (*Grus canadensis*), Golden Eagles (*Aquila chrysaetos*), and a number of hawk species (*Buteo spp*).

2.4.3 Post-Breeding Season

2.4.3.1 Bird Censuses

During the post-breeding season 11 surveys were completed in Parkview (1, 8, 20, 27 August, 10, 21, 26 September, 12, 17, 28, October and 7 November), 6 surveys were conducted in Thorncliffe (9, 28 August, 13, 29 September, and

22 October), and 3 surveys were completed in LaPerle (3, 21 August, and 11 November).

This season also had the highest average number of individuals/survey counted. The average number of birds counted in the more mature Parkview study area rose from 99.3 individuals/survey in the breeding season (Table 2.3) to 109.7 in the post-breeding season.

To test the hypothesis that the number of birds per survey were not the same in both seasons, a Kruskal-Wallis H-test was used. The H-statistic (3.67) which was less than the critical Chi-square (3.84, df=1, α=0.05). Therefore, the null hypothesis was rejected and it was concluded that the number of birds sighted during the post-breeding season were not significantly different from the number sighted during the breeding season.

In the younger Thorncliffe study area, the average number of birds counted increased from 54 individuals in the breeding season to 82.2 individuals in the post-breeding season. To test the hypothesis that the number of birds per survey differed in both seasons, a Kruskal-Wallis H-test was used. The H-statistic (1.815) which was less than the critical Chi-square (3.84, df=1, α=0.05). Therefore, the null hypothesis was rejected and it was concluded that the number of birds sighted during the post-breeding season were not significantly different from the number sighted during the breeding season.

Relative abundances for the post-breeding season were 548.5 birds km^{-2} in the oldest study area, 391.4 birds km^{-2} in the younger study area, and 4.55 birds km^{-2} in the youngest of the study areas. Newly fledged juveniles probably contributed to the apparent population increase. In addition a number of transients were seen in the two older areas.

In addition to the change in numbers, there was a change in the diversity of the populations between the breeding and post-breeding seasons. Using the Shannon-Weaver Index of Diversity (MacArthur and MacArthur, 1961), it was determined that the diversity decreased in both of the more mature areas of Parkview and Thorncliffe. In the Parkview area, the diversity dropped to 1.125 from 1.269 in the breeding season, while in the Thorncliffe Area the diversity declined from 0.909 in the breeding season to 0.872.

2.4.3.2 House Sparrow

The end of the breeding season for the House Sparrow (_Passer domesticus_) is marked by the formation of a number of more or less distinct flocks (Figure 2.12). The oldest subdivision, Parkview, had three such flocks which could be seen forming as early as 23 July 1990. These flocks grew in number until 12 October 1990. The largest group contained a maximum of 55 individuals, the intermediate sized group contained a maximum of 27, and the smallest of the flocks contained a maximum of 23. A nearest neighbour analysis of all House Sparrows in the Parkview area resulted in an R-value of 0.84. This result indicates that the individuals in the Parkview area were more clustered than they were during the breeding season (R=0.94).

In the less mature Thorncliffe area, two flocks of House Sparrows formed. The largest of these contained a maximum of 43 individuals while the smaller flock contained a maximum of 20. The geographic extent of the larger flock was approximately 2 ha while the smaller one appeared to range over 1 to 1.5 ha. Neither of these areas contained large numbers of conifers, but, they did contain an artificial feeding site. As in the older Parkview study area, there was an apparent increase in the number of sparrows observed between 1 August and 28 October.

Too few surveys were conducted in the 10-year-old subdivision, LaPerle, to make obvious the flock size in the post-breeding season.

2.4.3.3 American Robin

The number of American Robins (Turdus migratorius) declined steadily from a peak number observed during the breeding season (Parkview: 32 on 9 June, Thorncliffe: 10 on 5 May) in the oldest of the study areas to a minimum of 2 individuals on 20 August. The decline suggests that adults and juveniles began dispersing soon after fledging. The increase in numbers seen recorded on 27 August was attributed to migrants. This was largest number of individuals seen in the more mature Parkview area during the post-breeding season. Robins were not observed in the Parkview area after 26 September while in the Thorncliffe area they were not observed after 13 September.

To test the hypothesis that a different number of robins were seen in the Parkview study area and in the younger Thorncliffe study area, a Kruskal-Wallis H-test was used. The calculated H statistic of 0.343 was less than the critical value of 3.84 (df=1, α=0.05). As a result, the null hypothesis was rejected and it was concluded that there was no significant difference between the number of robins sighted in the two areas.

To test the hypothesis that the number of migrating robins seen in the three study areas was not correlated to the number of birch and coniferous trees, greater than 6m in height, a Spearman Rank Correlation test was used. The resultant rs of 1.0 indicated a perfect correlation between the variables. Consequently, the null hypothesis was rejected and it was concluded that the number of migrating robins, in each of the areas, was related to the number of coniferous trees and birch trees greater than 6m in height.

2.4.3.4 Chipping Sparrow

The number of Chipping Sparrows (_Spizella_ _passerina_) declined during the first week of the post-breeding season in the two oldest study areas. This decline suggests that both adults and young began dispersing soon after fledging had occurred. Chipping Sparrows were not observed in the Parkview study area after 1 August. On 9 August a single individual was sighted in the Thorncliffe area while on 28 August 20 individuals were observed in the same area. This increase appeared to represent a pulse created by migrants as this species was not observed in the Thorncliffe area after this date. Three Chipping Sparrows were observed in the LaPerle area on 21 August and these individuals appeared to be migrants as the species was not sighted within the area before or after this date. Migrants were not observed in the Parkview study area.

To test the hypothesis that the number of Chipping Sparrows counted in the three study areas were not the same, a Kruskal-Wallis H-test was used. The calculated H statistic (0.03) was less than the critical value of 2.7 (df=1, α=0.048), thus the null hypothesis was rejected and it was concluded that the number of Chipping Sparrows seen in the three study areas were not significantly different.

In an attempt to define which habitat features were associated with migrating Chipping Sparrows in Thorncliffe and LaPerle, a 2x2 contingency table, based on count data (Table 2.3) and vegetation data (Edgar 1992, Part 3), was used to test the hypothesis that the number of migrating Chipping Sparrows in Thorncliffe and LaPerle were proportional to the number of coniferous trees in the 3m to 6m height class. It was found that the chi-square (0.66) was less than the critical value of 3.84 (df=1; α=0.05). A second test table was used to evaluate the hypothesis that the number of migrating Chipping Sparrows in the two areas was not proportional to the number of birch trees in the 3m-6m height class (Edgar 1992, Part 3). The Chi-square value (0.143) was less than the critical value of 3.84 (df=1; α=0.05). In both cases, the null hypotheses were rejected and it was concluded that the number of migrating sparrows was proportional to the number of conifers and birch in the 3-6m height class. Since sparrows were not seen in Parkview after 1 August, that study area was not included in the comparisons.

2.4.3.5 Black-billed Magpie

Black-billed Magpies (Pica pica) were apparent throughout the post-breeding season in Parkview and Thorncliffe, but not in LaPerle. In the older Parkview area they were seen on a regular basis either singly or in pairs. Several birds were observed in small groups during July (3 pairs of 2 and 1 group of 4) and these groups became more common as the season progressed (2 pairs, 2 groups of three, and a single group of 6 during August). This species did not appear to have developed a preference for any particular type of habitat within the study area and individuals were often seen foraging throughout the area.

In the younger Thorncliffe study area, magpies were less abundant.

2.4.3.6 Blue Jay

In the 35-year-old Parkview subdivision, Blue Jays (Cyanocitta cristata) were observed, on a casual basis, throughout the months of August and September of 1990, outside of count periods, in small groups of 3 and 4 individuals. These groups appeared to represent family groups. As a consequence of these family groups, there was a marked increase in the number of individuals observed during this season. Although Blue Jays were observed throughout the study area, they avoided open areas such as the schoolyard where they were never seen.

In the less mature Thorncliffe area, Blue Jays were not observed during prior to 24 July or after 14 December, they were only apparent during the post-breeding season. Thus, it seems reasonable to assume that these individuals were either migrants or individuals dispersing away from the breeding areas.

Blue Jays were not observed in the most recently developed LaPerle subdivision.

2.4.3.7 Black-capped Chickadee

Observed numbers of Black-capped Chickadees (Parus atricapillus), in the Parkview study area, increased by a factor of nearly 3 in the post-breeding season over the breeding season. This increase indicates either the presence of migrants or individuals dispersing from breeding areas. After 12 October the apparent abundance of this species returned to levels experienced during the breeding season. This pattern suggests that many individuals disperse out of the study area.

Black-capped Chickadees were only apparent in the Thorncliffe area during the post-breeding season and they were not observed after 14 December. This suggests that the individuals sighted in Thornecliff were transients.

Black-capped Chickadees were not observed in the youngest of the study areas, LaPerle.

2.4.3.8 Sporadic observations

Two bird species were observed in the oldest of the study areas, Parkview, on an irregular basis in the post-breeding season though they are known to be resident in the urban environment. This includes the Northern Merlin (Falco columbiarus) and Cedar Waxwings (Bombycilla cedrorum).

2.4.2.9 Transients

The post-breeding season also includes the period of fall migration and a number of species were apparent for more or less of a short period at this time. The larids, particularly the Ring-billed Gull (Larus delawarensis), are a commonly observed urban bird during the post-breeding season, however, gulls were only sighted within the Parkview study area between 20 August and 26 September. In the younger Thorncliffe study area, these gulls were seen between 9 August and 22 October. This species was not observed in the LaPerle study area. Gulls were observed in large numbers along the banks of the North Saskatchewan River until 6 November when the overnight temperature dropped to -12°C.

In the oldest study area, Parkview, the Savannah Sparrows (Passerculus sandwichensis) were observed between 1 and 8 August. This species was not observed after 20 August and wasn't seen at all in the two younger study areas.

Dark-eyed Juncos (Junco hyemalis) were commonly seen in the oldest study area between 21 September and 28 October. The sightings were more or less evenly distributed between birds foraging on the ground (49%) and birds in trees (51%). This species was seen less commonly in the younger study area in Thorncliffe on 13 and 29 September. Juncos were not observed in the younger LaPerle study area.

There were also several bird species observed in small numbers that were migrants. From 27 August to 10 September, Yellow Warblers were observed during their fall migration, in the Parkview area. Also seen in this area were, European Starlings (Sturnus vulgarus), Pine Siskins (Carduelis pinus), Common Crow (Corvus brachyrhynchos), and a single White-breasted Nuthatch (Sitta carolinensis). These birds were not seen in sufficient numbers to make habitat relations apparent.

In the 20-year-old Thorncliffe area, only the European Starling and the Common Crow appeared as migrants. No migrants were observed in the youngest study area, LaPerle.

2.4.4 Winter Season

2.4.4.1 Population Density and Diversity

The winter season was considered to start after the first snowfall of the season which occurred on 11 November 1990. During this season, 13 surveys were conducted in Parkview (14, 27 November, 7, 26 December, 12 January, 2, 20 February, 5, 12, 19, 26 March, 2, 9 April), 4 surveys in Thorncliffe (14 December, 9 February, 9, 30 March) and 3 surveys in LaPerle (4 January, 3, 24 February). This season was characterized by the lowest average number of birds observed during the year. In the most established of the study areas, Parkview, the average number of birds observed was 95.4 compared with an average of 109.6 individuals/survey observed during the post-breeding season. In the younger area of Thorncliffe, the average number of individuals/survey observed was 38.4 which was less than the average 82.2 counted during the post-breeding season. In the least mature study area, LaPerle, the average number of individuals counted was 3.

To test the hypothesis that the number of birds per survey seen during the winter season was not the same as the number of birds per survey seen during the post-breeding season, a Kruskal-Wallis H-test was used. The calculated Chi-square (2.94) was less than the critical value 3.84 (df=1, α=0.05). Based upon these results, the null hypothesis was rejected and it was concluded that the number of birds per survey seen during the winter season was the same as the number of birds per survey seen during the post-breeding season.

The diversity of the species, using the Shannon-Weaver Index of Diversity (MacArthur and MacArthur, 1961), was also at the lowest value for the year. In the Parkview area the Index of Diversity was determined to be 0.674. In the Thorncliffe area the Index of Diversity was 0.171, the low diversity results from all species save the House Sparrow after 14 December 1990. The least mature of the areas, LaPerle, had an Index of Diversity 0.0 since all birds counted were House Sparrows. For all areas, there were fewer species and smaller individual counts than at any other time of the year.

The relative abundance, based upon the number of individual birds seen per survey, of winter birds ranged from an average 477 birds km^{-2} in the Parkview study area, 183 birds km^{-2} in the Thorncliffe area, and 13.04 birds km^{-2} in the most recently developed study area in LaPerle.

2.4.4.2 House Sparrow

The average number of House Sparrows (Passer domesticus), in the older Parkview area, increased from 74.17, during the post-breeding season, to 78.85 individuals (Table 2.3). In the less mature Thorncliffe area, the average number of individuals observed was 55.5 in the post-breeding season and the number declined to an average of 47 individuals observed during the winter season.

A Kruskal-Wallis H-test was used to test the hypothesis that there was no significant difference in the number of House Sparrows counted in the three study areas. The calculated value of H (10.96) was greater than the critical Chi-square value of 5.99 (df=2, α=0.05). Based on these results, the null hypothesis was rejected and it was concluded that there were significant differences in the number of House Sparrows counted in the three study areas.

The location of the flocks formed during the post-breeding season remained more or less constant throughout the winter season. In warmer weather House Sparrows appeared to disperse in patterns that were similar to those described in breeding season, while in colder weather the birds returned to more apparent flocks similar to those described in the post-breeding season. The sparrow population was characterized by this ebb and flow throughout the winter.

During colder weather (Temperature <-10°C) flocks of House Sparrows were observed perching in bushes and shrubs with some form of south facing reflecting surface behind. The reflecting surface was, most commonly, the outer wall of a garage and less commonly the reflecting surface was a fence. These surfaces appeared to function as windbreaks and heat reflectors which mitigated the effects of the cold. In extremely cold weather (temperature less than -30°C), such as occurred on 8 January 1991, House Sparrows were observed moving vertically in the trees. They were seen high in the trees at first light in an apparent attempt, by the birds, to minimize the effects of the extreme cold by means of heliotropism. As the sun tracked higher, the birds moved downward through the trees and later in the day House Sparrows were observed in protected bushes and shrubs. This response to extreme cold was observed in the Parkview and Thorncliffe areas. This behaviour was not observed in LaPerle, the youngest study area and probably this was a consequence of the small population size and low intensity of field observation.

House Sparrows were observed, on a number of occasions, leaving roosting sites at dawn. Most commonly, these roosting sites were in stands of coniferous trees, especially spruce greater than 6m in height, and birdhouses both of which were relatively close to feeders.

2.4.4.3 Blue Jay

In the older Parkview study area, the average number of Blue Jays (Cyanocitta cristata) vary slightly from the number observed during the post-breeding season (3.92 vs 4.25 respectively). Though this species was observed throughout the older Parkview area, they were not commonly associated with any particular type of habitat. Only 27.5% of the individuals sighted were found in association with coniferous trees. They were, however, common visitors at bird feeders which contained large seeds such as sunflowers. Blue Jays were not observed in the less mature Thorncliffe study area after 14 December and were not seen at all in the younger LaPerle study area.

2.4.4.4 Black-capped Chickadee

During the winter season the average number of Black-capped Chickadees (Parus atricapillus) observed in the older Parkview study area declined to 3.07 from an average 8.8 individuals/survey in the post-breeding season. Desrocher et al (1988) found winter flocks of chickadees to be site tenacious with an average of 8.1 individuals. While chickadees were seen in the Thorncliffe area during the post-breeding season they were not seen or heard in the Thorncliffe area after 14 December 1990 and they were not seen at all in the LaPerle area.

In the Parkview study area, three groups of chickadees were suggested in the data, however, these distributions were based on relatively low numbers of unmarked birds (Figure 2.14). Two of these group ranges appear to be partial. The individuals that remained within the study area were most often associated with deciduous trees (67%).

2.4.4.5 Black-billed Magpie

In the older Parkview study area, the number of Black-billed Magpies (Pica pica) increased from an average of 2.58 individuals/survey during the post-breeding season to an average of 5.46 individuals/survey during the winter season. Magpies were not observed in the Thorncliffe area after 14 December and they were not observed in the LaPerle area.

A number of roosting sites have been identified in the North Saskatchewan River valley (Reebs and Boag, 1987) and up to 20 individuals were casually observed (30 December 1990), by this author, flying towards known roosting sites at dusk. These sites were approximately 1.5 km. from the Parkview study area. The colonial roosting behaviour may account for the increased number of individuals sighted per survey, in areas near the roosts.

2.4.4.6 Northern Merlin

The Northern Merlin (Falco columbiarus) was observed in the Parkview study area on 3 occasions during the winter season. However, outside the formal count periods falcons were seen on 15 occasions. Merlins were not observed in either of the two younger study areas.

2.4.4.7 Red-breasted Nuthatch

The Red-Breasted Nuthatch (Sitta canadensis) was first observed in the Parkview study area on 27 November. Although this species was last observed on 2 February, casual observations indicate that it was present in the study area until 16 April. These birds ranged over an area of approximately 4 ha between 143 St. and 144 St. and between 89A Ave. and 90A Ave.

2.4.4.8 White-breasted Nuthatch

The White-Breasted Nuthatch (Sitta carolinensis) was observed in the older Parkview study area on a single occasion, 20 December 1990. This species was not observed in either of the younger study areas.

2.4.4.9 Common Redpoll

This species is irruptive in its winter distribution (Godfrey, 1986) and its distribution appears to be discontinuous in wintering areas. Casual observation has shown that, in past years (1988, 1989, and 1990), the Common Redpoll (Acanthus flammea) was a common winter resident in the mature Parkview area. This species was first observed on 7 December 1990 and remained in the study area until 20 March 1991. These small birds were commonly observed throughout the older Parkview study area which had a relatively large number of mature birch (Table 3.3) where they were often seen feeding on birch seeds. During formal census periods only nine individuals were seen of which 5 (55.6%) were in birch trees, 2 (22.2%) were in coniferous trees, and 1 (11.1%) was in a fruit-bearing tree. This species was not observed in the two younger study areas which had a smaller number of mature birch trees.

2.4.4.10 Pine Siskin

Pine Siskins (Carduelis pinus) were observed on only a single occasion and only in the oldest subdivision.

2.4.4.11 Northern Flicker

The Northern Flicker (Colaptes auratus) was observed within the Parkview study area on two occasions. Casual observation in past years (19 November 1989), suggests that this species is a common transient in urban areas. Its winter distribution is sporadic. Flickers have not been observed for extended periods during past winter seasons.

2.4.4.12 Bombycillids

Two species of the genus Bombycilla, B. garrula and less commonly B. cedrorum, were winter species in the urban environment. These species are irruptive in their winter distribution (Root, 1988) and sporadic in their local distribution. Both species occur in large mixed flocks.

Unpublished data collected in the area (Lange 1989), which includes the Parkview study area, during the annual Christmas Bird Counts, between 1979 and 1987, indicate that Cedar Waxwings comprised an average of 0.2% of the total number of waxwings counted.

During the winter season, a total of 37 Bohemian Waxwings were seen during the formal census periods. Of these sightings, 40.6% (15) were in Mountain Ash trees, 56.7% (21) were in a single Crabapple tree, and 2.7% (1) was perched on a powerline. Flocks of approximately 150 and 200 individuals were seen, respectively, on 26 December and 2 April 1991. These sightings were within the Parkview study area, however, they were not within formal census periods. A single Cedar Waxwing was seen on 2 April 1991. Neither of these species were seen in the two younger study areas.

2.4.4.13 Impact of Feeders

To determine the impact of bird feeders on the distribution of the winter bird population, the Parkview study area was sub-divided into 30mx30m cells. The total number of House Sparrows, Black-capped Chickadees, and Blue Jays was determined for each of these cells. Five cells, within the study area, were identified as containing bird feeders which were continuously supplied with bird seed throughout the winter season. The total number of birds observed, for each of the three species, was determined and an average value per survey for each site was calculated. Using a random number table (Campbell, 1989) ten additional cells were randomly selected and the total number of birds for the same three species was calculated. From these data, the average number of birds observed in each of the cells was determined. It was found that at the five feeder sites an average of 4.42 House Sparrows, 0.4 Black-Capped Chickadees, and 0.2 Blue Jays were observed per survey. At the ten randomly selected sites, an average of 0.9 House Sparrows, 0.02 Black-Capped Chickadees, and 0.05 Blue Jays were observed per survey. A Kruskal-Wallis H-test was used to test the hypothesis that the number of House Sparrows at feeders was the same as the number in the 10 randomly selected control areas. The calculated H-statistic of 6.0 was greater than the critical chi-square value (3.84, df=1, α=0.05). Therefore, the null hypothesis was rejected and it was concluded that there was a significant difference between the number of sparrows seen at feeders and in the control areas.

To test the hypothesis that the number of native species seen at feeders was the same as the number seen in the 10 randomly selected control areas, a Kruskal-Wallis H-test was used. The calculated H statistic of 53.47 was greater than the critical chi-square value (3.84, df=1, α=0.05). Therefore, the null hypothesis was rejected and it was concluded that there was a significant difference between the number of native bird species seen at feeders when compared with the control areas.

Therefore, it was concluded that bird feeders in winter appear to be significant attractants for all species. This is true whether native or exotic species are considered.

2.5 Discussion

2.5.1 Breeding Season

The number of species sighted, though not necessarily breeding, in the Parkview study area (10) was similar to the number of species counted by Savard (1978) in Toronto (9), Erskine (1977) in Ottawa (17), Erskine (1972) in Swan River, Manitoba (8), Erskine (1970) in Senne Terre, Quebec (8). In the Thorncliffe study area, 6 species were sighted, while only 1 species was sighted in the LaPerle study area. By comparison, Flack (1976) sighted between 12 and 22 species at several study sites within the aspen parkland of Alberta. Rukstad and Probst (1979) counted 25 species during the breeding season, within a mature aspen forest in Minnesota.

The bird population density in the three study areas, during the breeding season, was less than the densities found by Erskine (1972) in Swan River, Manitoba (609 km^{-2}), Savard (1978) in Toronto (up to 763 km^{-2}), and Spiers et al (1970) in 10 Ontario cities (1,344 to 2,637 km^{-2}). Breeding bird densities in aspen forests were also higher than the bird densities in the Edmonton study areas. This includes Flack

(1976) who found densities between 1027 and 1703 km^{-2}, Erskine (1975b) counted 686 km^{-2} in a British Columbia poplar forest, and Rukstad and Probst (1979) who found 810 km^{-2} in a mature Minnesota aspen forest.

The Shannon-Weaver Index of Diversity, the evenness of distribution of the individual birds among the species present, decreased from the older Parkview area to the youngest LaPerle study area.

The distribution of species and the population density of breeding birds in the Edmonton study areas was contrary to the general findings of Campbell and Dagg (1976) who determined that the number of species increased with distance from the city centre and also that the population density was greater in urban areas as compared to rural areas. In this study, the largest number of species occurred in the oldest study area and the least number occurred in the youngest study area. The highest density occurred within the most mature of the study areas and lowest density was in the youngest study area. Thus, a gradient can be defined from the oldest, residential study area, toward the more recently urbanized suburbs on the city edge.

Based on the results it can be concluded that the urban environment is characterized by a relatively low diversity and density of breeding birds. Emlen (1974) attributes such differences to a simplification in the urban avian habitat when compared with wildland habitats.

In this study, House Sparrows, American Robins, and Chipping Sparrows accounted for 88.3% of all observed birds in Parkview, 63.3% in Thorncliffe and 100% in LaPerle. Erskine (1972) found that these same species accounted for 87% of the birds observed in Swan River, Manitoba, Campbell and Dagg (1976) determined the same three species accounted for between 6% and 55% of the breeding population in their Waterloo, Ontario study, Weber (1975) found that two of these species (Chipping Sparrows were not present) accounted for 71% of the nests located in Vancouver, B. C. and Savard (1978) determined that these three species accounted for between 31% and 58% of the breeding population in a number of Toronto study areas. By contrast, Gotfryd (1979) found that robins and House Sparrows accounted for only 8.1% of the breeding birds in an mixed deciduous forest near Missassauga, Ontario. Nasmith (1979) determined that robins accounted for 14% of the breeding birds in a wooded city ravine in Toronto (Chipping Sparrows and House Sparrows were not seen). Rukstad and Probst (1979) found that robins accounted for 0.7% of the breeding birds in a mature aspen forest in Minnesota, and Flack (1976) determined that robins (House Sparrows and Chipping Sparrows were not seen) accounted for between 5.3% and 9.5% of the birds in three non-urban study sites in central Alberta. The greater proportion of House Sparrows, American Robins, and Chipping Sparrows in urban bird populations suggests that these species have benefitted from the process of urbanization.

Overall, it was determined that there was a statistical correlation between the total number of House Sparrows and Robins counted in the three study areas during the breeding season and the number of coniferous trees in excess of 6m in height.

The ground-nesting, shrub-nesting, cavity-nesting, and canopy-nesting birds appear to be limited in their breeding distribution by human disturbance and discontinuities created by the unnatural association of tree varieties (Edgar 1992, Part 3). The day-to-day human activities, such as lawncutting, children playing, and other social activities, exclude ground-nesting birds and shrub-nesting birds from most urban habitats. A list of species found in the Aspen Parkland of central Alberta can be found in Flack (1976). The exclusion results since many breeding birds will desert a nest site when it is subjected to the threat of attack, whether the threat is real or perceived (Harrison, 1984). As a consequence, these relatively low levels of disturbance may be a factor which causes some bird species to avoid use of urbanized environments. This reaction by birds may explain in large part why the urban habitats support a low diversity of breeding bird species.

The bird species which were observed nesting within the study areas utilize sites at heights which minimize their interactions with humans and thus minimize the potential threat to the nest site and their young. The breeding birds observed in the three study areas have been reported (Godfrey 1986) to nest at heights ranging from 2 to 15m above ground. This speculation is supported by the findings of Weber (1975) who reported that 97% of the nest-sites examined in Vancouver were at heights in excess of 3m. This zone may be far enough above potential threats from human activities to encourage these species to attempt nests. It follows that absence of this habitat would select against these species occupying areas lacking tall shrubs and trees.

2.5.1.1 House Sparrows

The House Sparrow was the most numerous bird within the three study areas. The total domination of nest-boxes by House Sparrows within the Parkview study area may be a factor which has resulted in the exclusion of their native species. Some area residents reported that native cavity nesters such as Purple Martins (_Progne_ _subis_) and Tree Swallows (_Tachycineta_ _bicolor_) were present as little as a decade ago.

Sparrow use of 85% of the available cavities within light standards suggests that the availability of nest-boxes has not limited their numbers within the study area. The difference between the number of individuals observed at known nesting sites and the total number of sparrows counted (an average of 27 birds per census) suggested that a sizeable proportion of the population was either not breeding within the study area or they were nesting at sites which were not identified.

Authors such as Werler and Franks (1975) have documented their versatility in selecting suitable nest sites and several authors have noted their use of deciduous and coniferous trees as nest sites (Savard 1978, Campbell and Dagg 1976, and Weber 1975). In the two younger study areas, many obvious nest-sites were not used suggesting that there was potential for expanding the population. The observations at Edmonton are contrary to the observations of Weber (1975) who determined that 91% of the House Sparrow nests observed in Vancouver were located in crevices or enclosed spaces within buildings, while only 5.3% of House Sparrows nested in bird boxes. Campbell and Dagg (1976) report similar nesting habits, but did not quantify their results. Savard (1978) found that 86% of nesting House Sparrows used man-made structures as nesting sites. It would appear that either the nesting behaviour of House Sparrows or construction practises differ between the regions.

Breeding behaviour was evident in the House Sparrow populations in Parkview and Thorncliffe at the beginning of the study period and observations the following winter indicate that these behaviours were apparent by early February. Murphy (1978) reported that clutch initiation occurred on 31 March 1976 and 19 April 1975 for a population of House Sparrows near Calgary, Alberta and these results are similar to the generalizations reported by Erskine (1976). Murphy also found that the breeding season for the Calgary populations of this species started later and was of shorter duration when compared with populations in Lawrence, Kansas (Calgary: 70 days, Lawrence: 81 days). Clutch initiation data was not collected for the Edmonton study areas and therefore comparisons were not possible.

2.5.1.2 American Robins

Singing male robins selected different types of trees for singing posts in the Thorncliffe and Parkview study areas. Robins in the older Parkview study area showed a preference for coniferous trees greater than 6m in height and overhead powerlines, while robins in the younger Thorncliffe area showed a preference for birch and Manitoba Maple trees.

American Robins arrive before the deciduous trees are in full-flush, consequently, the first nest-sites, in Parkview, were often selected in the distal ends of branches in conifers (1990:5 of 9; 1991:6 of 8) which provided a degree of crypticity for the nests. There appeared to be a greater proportion of second nests located in deciduous trees (1 of 8 vs 4 of 6). This shift in the preference in nesting sites may have been a function of the extent of leaf growth of deciduous trees early in the breeding season. In a study of nest-sites in Vancouver, Weber (1975) found 8 of 15 robin nests were located in deciduous trees and 3 of 15 were in coniferous trees. Savard (1978) found 61 of 171 nests were located in deciduous trees and 33 of 171 were in coniferous trees. These results indicate a preference by breeding robins for nesting in deciduous trees. The difference between these results and the present study suggest that breeding robins were adapting their nesting behaviour to the available habitat. Two broods were known to be raised by some of the robins and double or even triple broods are common for American Robins (Salt and Wilk 1966 and Erskine 1976). The results indicate that second nests were more common in deciduous trees and therefore the nest-site preference appears to be more similar to more southerly populations.

In the Thorncliffe study area, only two nest sites were located and this was too small a sample upon which to base conclusions. It is, however, worth noting that there appeared to be an abundance of trees capable of providing nest sites at heights between 2m and 6m. The robin territories in the Thorncliffe study area were on average larger than those in the Parkview study area and this difference in size was statistically significant.

The lower density of breeding American Robins in the Thorncliffe area would likely result in less competition for breeding territories and may have resulted in their somewhat larger size. While the number of coniferous trees within each territory was not significantly different, however, a comparison of the number of breeding territories to the number of trees in excess of 6m in the two study areas indicated that the two factors were statistically related. It is possible that the breeding density of robins was limited by the availability of singing posts rather than the availability of potential nest sites. These results suggest that a decrease in the size of breeding territories with a concomitant increase in the number of territories could be expected as the tree cover in Thorncliffe ages.

In this study, it was determined that the breeding density for robins in the Parkview study area was significantly larger than the density in Thorncliffe. In Wisconsin, Emlen (1984) found the breeding density of robins to range from between 16.2 and 18.3 pairs km^{-2} with an average territory size of 2.2 ha. The breeding density of American Robins in both the Thorncliffe and Parkview areas was also considerably higher than the 0.0 to 0.4 ha^{-1} recorded at 8 logged study areas in Minnesota by Niemi and Hanowski (1984). Mannan et al (1984) found that robins occurred with an equal density of 0.057 pairs ha^{-2} in the old growth forests and managed forests in Oregon. Bock and Lynch (1970) found that breeding robins were more than 6 times more common in burned forest plots than in unburned plots.

The difference in abundance, between wildlands and urban areas, can probably be attributed to the extensive open areas, such as lawns, and the availability of tall trees which serve as singing posts. This also appears to explain the difference between residential areas.

2.5.1.3 Chipping Sparrows

Although no nest-sites for Chipping Sparrows were located, the breeding territories were mapped in both Parkview and Thorncliffe during the 1990 breeding season. It was determined that the size of the these territories was not significantly different for the two study areas. Bent (1968) reported that the average size of breeding territories, in Michigan, was between 0.4 and 0.6 ha. These values are similar to the size of breeding territories found in the Thorncliffe and Parkview study areas which do not vary significantly in size.

It was also found that, statistically, the number of Chipping Sparrows' territories in the two study areas was proportional to the number of coniferous trees between 6 and 9m in height. The small number of trees which meet these parameters (Edgar 1992, Part 3) in LaPerle probably accounts for the lack of breeding pairs in that study area.

The breeding density of Chipping Sparrows was higher in the Parkview and Thorncliffe study areas than in wildlands. Mannan et al (1982) found that Chipping Sparrows in an old-growth Oregon forest had a breeding density of 0.33 pairs ha^{-1} while in managed forests, which were characterized by fewer large trees and greater tree height diversity, supported 0.80

pairs ha^{-1}. Niemi and Hanowski (1984) determined the breeding density in 3 of 8 logged study areas in Minnesota to range between 0.1 and 0.2 pairs ha^{-1}. Bock and Lynch (1970) found a breeding density of 0.056 ha^{-1}. Chipping Sparrows in a burned forest while none were seen in an unburned forest study area. The difference between the density in urban wildland populations can probably be attributed to the Chipping Sparrow preference for an open habitat with an abundance of small trees and ground cover (Sedgewick 1987).

2.5.1.4 Impact of domestic pets as predators

Introduced predators, such as domestic cats, may also have some impact on breeding birds, especially those which nest at low height. Anecdotal information regarding domestic cats ranges through the whole spectrum of potential impacts. Some cat owners contend that cats have virtually no impact on urban birds while others contend that cats are significant urban predators. Very little data regarding the relationship between cats and birds is available in the literature. It is most likely that domestic cats would have their greatest impact on breeding birds at the time the young are fledging, since they have limited flight capability and little experience with predators.

Most studies involving cats (Calhoon and Haskel, 1989; Liberg, 1980) have been limited to feral cats since they may be marked with identification tags without raising the ire of cat owners. These studies were also conducted in areas where the climate was less extreme than that of Edmonton and this may have some effect on the interpretation and application of the results obtained. Although there are insufficient local data to determine the true impact of cats on urban birds in Edmonton, it is salient to note that Calhoon and Haskel (1989) noted only a single instance of predation in 180 hours of observing 114 urban cats over three sixty day periods in autumn 1981, spring 1982, and autumn 1982.

2.5.1.5 Enhancing the urban environment for breeding birds

Overall, urbanization has resulted in a number of environmental conditions which appeared to limit the distribution of breeding birds. The height and development of coniferous trees was the most widespread limiting factor of the urban environment. Notwithstanding this limitation, a number of long-term goals (Edgar 1992, Part 3) and short-term goals may be set which will serve to enhance the quality of the urban environment as it affects the distribution of breeding birds.

In the short-term, residents may be able to affect the abundance and diversity of breeding birds by providing water, nesting sites, and nest materials (Hough 1989). Standing water is at a premium during the breeding season and there is anecdotal information which suggests that the erection of a bird bath may influence the territorial boundaries of some breeding birds, such as American Robins (Boag, pers. comm.). Proper siting and construction of nest boxes is crucial if particular species are to be encouraged to nest. Specifically, the size of the entry hole can be used as a means of attracting smaller birds, such as wrens and chickadees, while excluding exotic species such as House Sparrows. In satisfying these short-term goals, there is again a distinct role for existing city agencies such as nature centres and conservatories. It is, however, imperative that these agencies disseminate information which is relevant and applicable to urban areas with similar climatic regimes as well as similar assemblages of breeding birds.

2.5.2 Post-breeding Season

The beginning of the post-breeding season was contiguous with the end of the breeding season which was marked by a breakdown of breeding territories as evidenced by the lack of obvious breeding behaviours.

Post-breeding season data for the purposes of comparison, could not be found within the literature. No studies have been published on urban areas with a similar habitat structure. The study by Savard (1978) found that, during the post-breeding season, both the density and diversity of birds in urban Toronto to be higher than Edmonton.

A gradient can be defined using population density or the Shannon-Weaver Index of Diversity. The greatest density of birds was found in the older Parkview study area, while the lowest density was found in the youngest LaPerle area. The intermediate aged Thorncliffe area had a density between these two extremes. A similar gradient is apparent in the Index of Diversity. In the youngest area, Laperle, the index indicated that the birds counted were more evenly distributed between the species present than the birds counted in either of the older study areas, Parkview and Thorncliffe.

Early in the post-breeding season, House Sparrows showed increased numbers in association with feeders which were continuously stocked with seeds. In the Parkview study area, each of these flocks occurred within a 1 ha area which contained at least one artificial feeding site (Figure 2.12). During this season, the number of individuals observed increased somewhat over the breeding season. This increase probably resulted from the increased observability as the nesting sites were abandoned and the flocks form. The number of young fledged also likely accounts for the increase in numbers.

The declining number of American Robins and Chipping Sparrows suggests that these species began dispersing almost as soon as the breeding season ended. The later increase in numbers of the same species appeared to represent the transience of a different migrating population. Confirmation of this hypothesis would require the marking of the breeding birds within the study areas.

Migrating Chipping Sparrows showed a statistically significant preference for the Thorncliffe study area which had an abundance of birch and coniferous trees in the 3-6m height class. This represented a shift toward trees that were shorter than those preferred during the breeding season and also included birch which were not a preferred species during the breeding season. The lesser number of trees in the 3-6m height class appears to explain the absence of this species in the older Parkview area and the younger LaPerle area.

By contrast, migrating Robins displayed a statistically significant preference for the older Parkview area. This preference suggests that migrating robins were selecting areas with characteristics similar to those preferred during the breeding season which were trees greater than 6m in height. Parnell (1969), who noted similar preferences in migrating parulids, found that 98% of migrating Yellow Warblers (based on 51 observations) preferred wet thickets which were similar to the habitat selected for breeding. Migrating Robins were not apparent in the LaPerle area.

Although evidence for breeding was not directly observed, anecdotal information suggests that Blue Jays and Black-capped Chickadees breed in the more mature urban habitats and the increase in the number of individuals observed from both species during the post-breeding season would seem to support these speculations. The sudden appearance of both species in the less mature study area, Thorncliffe, during the post-breeding season and their complete absence from this area during the breeding season suggests that a significant number of individuals, possibly juveniles, were dispersing or migrating through the urban environment. Weise and Meyer (1979) found that juvenile Black-Capped Chickadees, in 3 study areas, dispersed approximately 3 weeks after fledging. They also determined that these birds moved between 0.4 and 11 km from the nest site. The average distance travelled was 1.1 km. In order to confirm patterns of distribution and dispersal in urban chickadees and jays it would be necessary to use marked birds.

Species which were permanently resident in the urban environment began to establish distribution patterns which would be more or less maintained until the next breeding season. This was most apparent in the flocking behaviour of the House Sparrows and these observations were supported by a nearest neighbour analysis which indicated that this species was more clustered during the post-breeding season than during the breeding season.

2.5.2.1 Relationship between Savannah Sparrows and birch trees

Savannah sparrows are among the first transients to appear in the urban environment and, in Parkview, the widespread occurrence of mature birch (Figure 3.8) appears to have a positive influence on the distribution of this species which was observed between 1 August and 20 August 1990. Casual observation from 1988, 1989, and 1991 showed that the Savannah Sparrows arrived in the Parkview study area during the third week of July.

Birch trees, which are a common ornamental in residential areas dating from the 1950's and 1960's, are subject to infestation by the burrowing larvae of three species of sawfly (_Fenusa pusilla_, _Heterarthus nemoratus_, _Profenusa thomsoni_) (Drouin and Wong 1984). While these insects do not seriously harm the trees, they do cause serious degradation in their aesthetic quality. As a consequence of the damage caused by sawfly larvae, birch trees have fallen into disfavour as a suburban ornamental (Ives and Wong, 1988). From late July through the month of August, 48% of the Savannah Sparrows, which are ground dwelling birds (Godfrey 1986), were observed foraging on the ground. A further 17% of individuals were observed on fences and lawns while the remaining 35% were observed within the crowns of trees.

The sawfly larvae, which hatch from eggs laid by the female sawflies in the birch leaves, pupate in the ground layer after dropping from the leaves. The Savannah Sparrows appeared to gorge on the large number of larvae which drop from the leaves of trees which have either not been treated with a biocide or which have been treated irregularly with a biocide.

A 1977 study of leafminers in the Winterburn area by Cerezke (unpubl.) indicated that all three species of sawfly larvae could be present in birch trees during the same time frame that the Savannah Sparrows were present in Parkview. Leafminers were collected by Cerezke and it was found that P. thomsoni, the most common form of leafminer in urban trees, began dropping from the leaves on 20 July. The second generation of F. pusilla began dropping on 14 July and the H. nemoratus were collected from 11 July onward.

These observations suggest that Savannah Sparrows may be at risk through the ingestion of quantities of biocides, principally Dimethoate an organophosphate biocide commonly sold under the trade name Cygon 2E. There were no available data regarding the level of organophosphate usage by private landowners within the urban environment, however, Dimethoate is one of a number of biocides recommended for the control of leafminers (Drouin and Wong 1984, Knowles 1989). Ware (1978) has questioned the efficacy of this biocide in the control of common insect pests. Ware notes that while organophosphates are not persistent, they are more toxic to vertebrates than the organochlorines. The immediate negative effects of organophosphates on living organisms have been known for many years (Carson, 1963). There are also data which suggest that organophosphates, in mammals and insects, breakdown to form more persistent phosphorate and phosphorothiolate toxins (Miyamoto 1972).

This apparent association warrants further investigation to determine the concentration of biocides in the leafminers and to determine whether or not organophosphates are impacting the Savannah Sparrows.

2.5.3 Winter Season

In this study, an average of 477 birds km^{-1} were seen in the oldest Parkview study area, in the younger Thorncliffe area the average density was 183 birds km^{-1}, while in the youngest study area, LaPerle, the average density was determined to be 13 birds km^{-1}. The number of birds in the three areas was statistically related to the number of coniferous trees in excess of 6m in height. A number of other urban studies have also estimated winter population densities.

Ralph (1982) found the population density in Ignace, Ontario to be 251 birds km^{-1}, while in Ottawa Erskine (1975a) estimated the winter bird population at a density of 472 birds/km^2. Weber (in Savard 1978) found a maximum winter population of 1241 birds/km^2 in Vancouver and Savard (1978) found the maximum winter population density in Toronto to be 1942 birds/km^2. A number of other studies have yielded similar results for winter population densities within various urban habitats, such as parks, (Fairfield 1981 and 1982, Smith 1982, and Erskine 1979). It was apparent that the winter population density in Edmonton was near the low end of the range when compared to other urban centres. It should, however, be noted that Edmonton is located further north and has a more extreme climate than any of the other centres.

Few winter bird census results could be found for urban areas with climatic and ecological similarities to Edmonton. None could be found for censuses in the Canadian prairie provinces. Bodner (1989) determined the population density to 1008 birds km^{-2} in a Cottonwood-abandoned field habitat near Larimer, Colorado. Also in Colorado, Ryder and Ryder (1979) found a population density of 778 birds km^{-2} in Cottonwood-Willow riverbottom. These densities were markedly higher than those found in Edmonton.

The winter population in the Parkview study area was comprised of 11 species, Thorncliffe of 4 species, while in LaPerle, only a single species was seen. In other urban studies, Erskine (1979) found 9 species in Sackville, New Brunswick, and Ralph (1982) totalled 9 species in Ignace, Ontario. In southern Ontario the number of species encountered ranged from 4 to 23 (Savard 1978, Fairfield 1981, Fairfield 1982, and Smith 1982). The data collected in this study was near the mid-range of all these southern Ontario studies.

The House Sparrow was encountered in all of these studies, and comprised between 19% and 52% of the total bird populations (Savard 1978, Erskine 1979, Erskine 1982, and Smith 1982). By comparison, House Sparrows accounted for an average 82% of the birds counted within the Parkview study area, 98% of the winter bird population in Thorncliffe, and 100% of the birds seen in LaPerle. This higher proportion of this species in Edmonton's avifauna may reflect the more limiting climatic conditions or habitat characteristics working singly or in combination. Isolating causal variables is an area for future study.

In Edmonton, Spencer (1975) inventoried the wildlife in four ravines along the North Saskatchewan River valley. In the winter of 1973 he found a total of 30 bird species in the ravines. The Parkview study area is less than 1 km from one of these study sites, Mackenzie Ravine, and less than 3 km from a second site, Whitemud Ravine. In Spencer's results, 6 of the species recorded in Mackenzie Ravine and 9 of the species seen in Whitemud Ravine were recorded in the Parkview study area. Only the Pine Siskin and Red-breasted Nuthatch were limited to the residential area. All of the species seen in Thorncliffe were recorded in Spencer's inventory.

In wildland censuses, which were similar in habitat or latitude, the number of species and the population density of winter birds was less than the density of winter birds in Edmonton while the number of species was higher. Near Banff, Alberta, Colgan et al (1978) found 15 species at a density of 80 km^{-2}, Kingery and Kingery (1975) counted 19 species of winter birds at a density of 463 km^{-2}, and Harris (1975) determined the population density near Saskatoon, Saskatchewan to be 328 km^{-2} and comprised of 15 species.

2.5.3.1 House Sparrow

The House Sparrow was the only species seen in all three areas throughout the winter season. It was the only species seen after 14 December 1990 in the Thorncliffe area and it was the only species seen in the youngest study area, LaPerle. The number of individuals seen in each of the areas varied significantly.

The winter behaviour of this species at higher latitudes is not well-documented in the literature. Anecdotally, it is common to see sparrows in bushes and shrubs which provide exposure to the sun and protection from the winds. With a wall or fence behind, this behaviour appears to mitigate the effects of the cold. It was noted, on 8 January 1991, when the air temperature was -30°C that the sparrows moved to the crown of a birch at dawn. As the sun rose, the sparrows moved downward through the tree. This was perceived as an attempt to mitigate the effects of the extreme cold. This behaviour does not appear to have been documented in the past.

2.5.3.2 Impact of Artificial Feeders on Winter Bird Distributions

The older subdivision of Parkview supported the largest bird population while the younger study areas supported significantly fewer birds and after 14 December only a single species, the House Sparrow, could be found in either the Thorncliffe or LaPerle study areas. The reasons for this difference were not clear, for each area contained a number of bird feeders and in the intermediate aged, Thorncliffe, there appeared to be sufficient trees to provide shelter from winds and storms. This disparity in winter bird distribution requires a great deal more study to define the role of habitat and artificial feeding sites.

An analysis of the field data collected during the 1990/1991 study period showed that exotic bird species were more common near artificial feeding sites. The low average number of native bird species seen at bird feeders suggests chickadees and Blue Jays were less dependent on artificial feeding sites than exotic species. Desrocher et al (1988) determined that supplementary feeding of chickadees did not result in a significant increase in breeding success. Manjit and Boag (1990) found that while supplementary feeding of magpies had no effect on the clutch size, there were several positive effects. They found that clutch initiation was advanced up to 7 days, there was a higher survival rate of nest contents during a spring storm (71% survival), there was an increase in the fledging success (78%), and an increase in the rate at which the nestlings gained weight. This study also suggested that the impact of supplementary feeding may be related to the type of food provided.

An analysis of the distribution of these bird species suggest that artificial feeding sites were greater importance to both exotic and native bird species. The extent of winter ranges for urban populations of species such as Black-capped Chickadees and Blue Jays is not clear and further elucidation of their distribution would require the use of marked birds.

2.5.3.3 Irruptive Species

Two genera of overwintering birds are irruptive in their distribution; Redpolls and Waxwings.

Large flocks of waxwings were commonly seen throughout the city during the winter season of 1990-1991, however, they were not regularly seen in the older Parkview area. This probably reflects the early time of day during which birds were counted. The behaviour of the birds observed, only small numbers were counted, suggested that the large flocks disperse into smaller groups when roosting. Neither species of waxwing were sighted in either of the younger study areas.

Waxwings feed on the fruit of the Mountain Ash (*Sorbus* spp.) trees commonly planted as ornamentals in the city after World War II (J. Switzer pers. comm.) and on Crabapple trees (*Malus* spp.) which are also a common urban ornamental (Salt and Wilk 1966). Given the sporadic distribution patterns of both species of bombycillids, it was not possible to identify an historical correlation between the growth of the city, the growth of the fruit bearing trees, and the number of waxwings utilizing the city. Notwithstanding these limitations, the low number of waxwings showed a preference for the fruit-bearing trees (97.3% of sightings).

Casual observations over several years (winters of 1988, 1989, and 1990) suggest that, when not feeding, mature poplar trees were favoured perching sites for the flocks of waxwings. Such trees appeared to provide adequate perching opportunity for large flocks. In addition, by perching within the crown of the tree there appeared to be some degree of protection from urban predators such as the merlin.

Common Redpolls are winter residents commonly seen in association with birch trees in the urban environment (Salt and Wilk 1966). Although only a small number of the birds were seen during the census periods, this association was observed in the Parkview study area where 55.5% of the individuals seen were in birch trees.

2.5.3.4 Supplemental Feeding of Winter Birds

In winter, residents can significantly affect the number of birds by providing urban birds with access to food. In this study, the greatest density in bird populations occurred in and about bird feeders in the Thorncliffe and Parkview study areas. However, these are established areas with a more or less well-developed tree cover and the role of habitat cannot be overlooked (Edgar, Part 3).

Access to a consistent food resource is requisite to the winter survival of many urban birds and this is especially true of exotic species such as the House Sparrow. Overwintering House Sparrows in Churchill, Manitoba were found to expend approximately 151 Kjd^{-1} (Kendeigh in Gill,1990) which is almost 30% higher than the 117 Kjd^{-1} required in the warmer seasons. This increased energy requirement must be satisfied during the shorter winter day. It seems reasonable to presume that to satisfy this increased need the birds would be compelled to devote a greater proportion of their time to food foraging activities. These energy demands can be more or less easily satisfied at artificial feeding sites.

A variety of seed types are available to urban residents who wish to feed birds in winter. These include commercial mixes, confection sunflower seeds, and commercial sunflower seeds (oilseeds). Seeds can be supplemented by suet feeders which are particularly attractive to chickadees, woodpeckers, and nuthatches. Larger birds can be attracted with unshelled roasted peanuts. Jays and magpies have been observed by this author, on a regular basis, flying up to six city blocks to a feeder containing peanuts. A number of popular guides to bird feeding are available, and some, such as Waldon (1990), are specifically directed at feeders being used on the Canadian prairies.

2.6 Conclusion

In all seasons, a gradient in the bird population occurred from the oldest, most central study area toward the youngest study area which was on the urban fringe. The oldest study area had the highest bird population density and the greatest number of species, while the youngest study area had the lowest density and the least number of species. The Shannon-Weaver Index of Diversity results provided confirmation of this gradient. The individuals were more evenly spread among the species present in the oldest study area and were less evenly distributed among the species present in the oldest study area. These gradients were contrary to results of Campbell and Dagg (1976) who maintained that the density and diversity in the bird population increased toward the rural areas.

During the breeding season, the density of birds in the three study areas was found to be less than the density of birds in aspen forests in central Alberta and less than the density of breeding birds determined in other urban studies. The number of species tabulated was similar to the number of species recorded in other urban studies, but, markedly less than the number of species found in wildland studies. In the winter season, the density of the urban population was greater than the population density in wildlands, although the number of species counted was less in the urban areas. The population density in the Edmonton study areas was less than that of other large urban centres and more than the density of the bird population in some smaller urban areas. There were no data available for comparison to the results for the post-breeding season.

The urban environment was dominated, in all seasons, by the House Sparrow, an exotic species. The greatest number of individuals occurred in the older, more mature study area. It was the only species nesting in the youngest study area and in this sense may be considered a pioneer species. House Sparrows were more dispersed during the breeding season and less dispersed during the post-breeding and winter seasons. Early in the post-breeding season they began forming flocks with bird feeders as a nucleus. The patterns persisted through to the end of the winter season. The distribution of artificial feeding sites was found to be an important factor in the distribution of exotic bird species, such as House Sparrows.

The popular belief is that birds begin to establish winter feeding territories late in the post-breeding season and residents are encouraged to start feeding birds in October. The data from this study suggest that patterns of dispersal for resident bird species did not vary significantly after the end of the breeding season and that these patterns were maintained throughout much of the winter season. Thus it would seem prudent, for urban residents who wish to attract increased numbers of birds, to begin supplying artificial feeding sites with seed much earlier than is currently recommended. By providing a reliable food resource for birds in the process of establishing post-breeding distribution patterns, some species may be induced to remain in a specific area through to the following breeding season.

Some native species, such as American Robins and Chipping Sparrows, were at higher breeding densities than was found in breeding bird censuses conducted in wildlands. During the breeding-season these two species were associated with different habitat components within the urban environment. Migrating individuals of these species showed a preference for urban areas which were structurally similar to areas favoured for breeding. Urbanization has resulted in a number of environmental conditions which affect the distribution of native bird species. A number of overwintering species, such as redpolls and waxwings, appear to have developed a dependence on fruit-bearing and seed-bearing trees in the mature Parkview study area. In the post-breeding season, a relationship was identified between Savannah Sparrows and the larvae of sawflies, which are commonly found in urban birch trees.

The results from the three study areas indicate that the number of coniferous trees greater than 6m in height was the most widespread limiting habitat factor for birds in the urban environment.

Overall, this study highlights the limitation in the current level of knowledge regarding the ecology of the urban avifauna and the almost total lack of comparable studies in urban areas with similar climatic and environmental features. This study also provides baseline data for further inquiry into the biogeography of urban birds within the City of Edmonton.

2.7 Figures

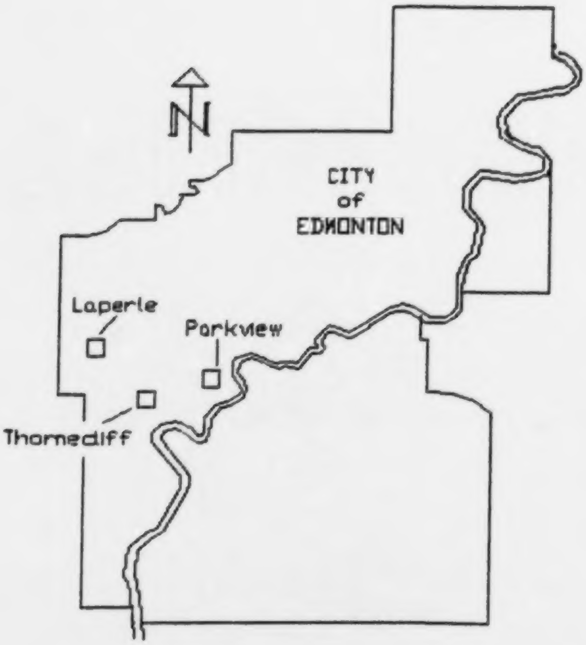

Figure 2.1: The location of the three study areas within the City of Edmonton (Not to Scale).

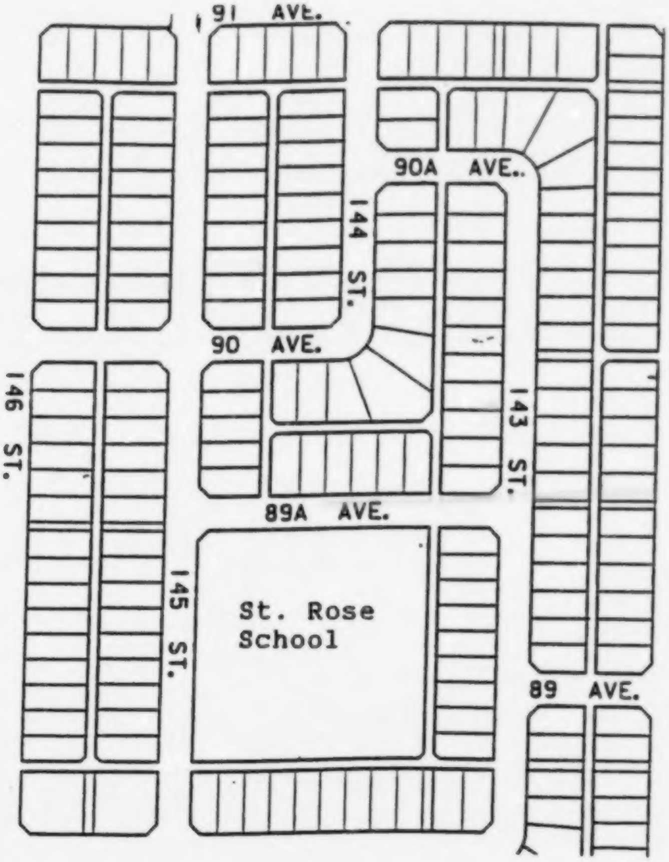

Figure 2.2: The Parkview study area (scale 1:4300). This was a 20 ha portion of a subdivision that was constructed between 1955 and 1960. North is to the top of the page.

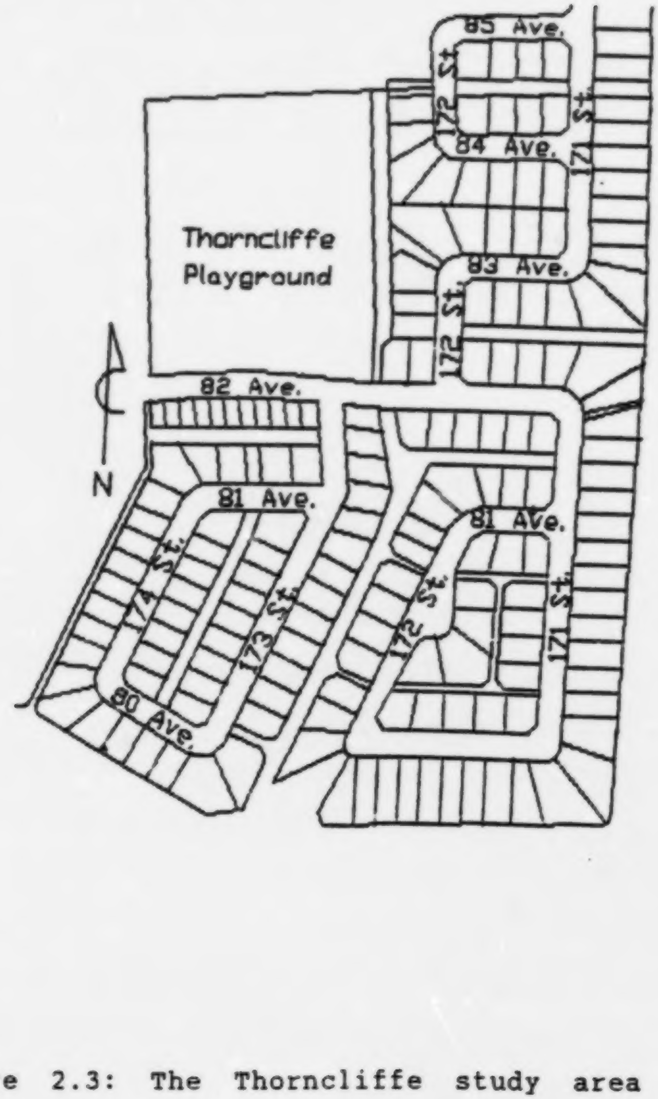

Figure 2.3: The Thorncliffe study area (scale 1:5000) was a 21 ha portion of a suburban area was constructed in the early 1970's.

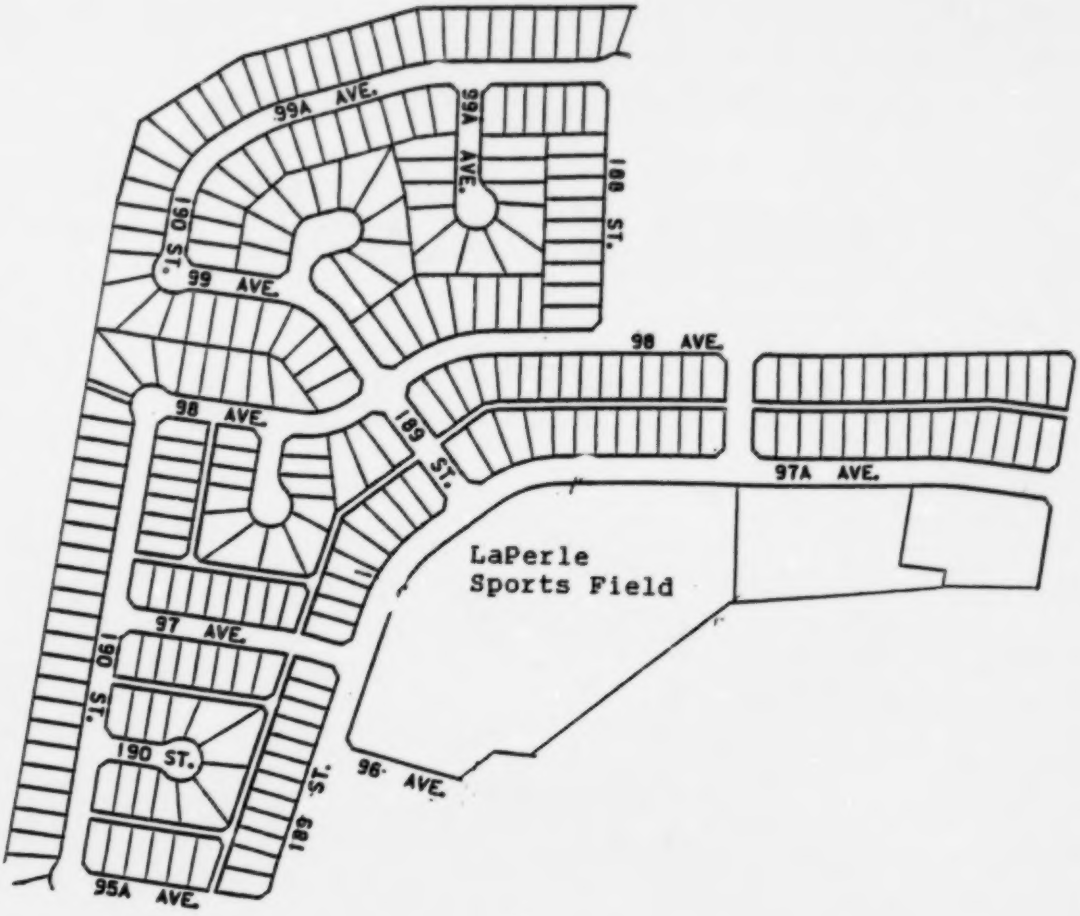

Figure 2.4: The LaPerle study area (scale 1:4200) was a 22 ha portion of a subdivision was constructed in the mid-1980's. North is to the top of the page.

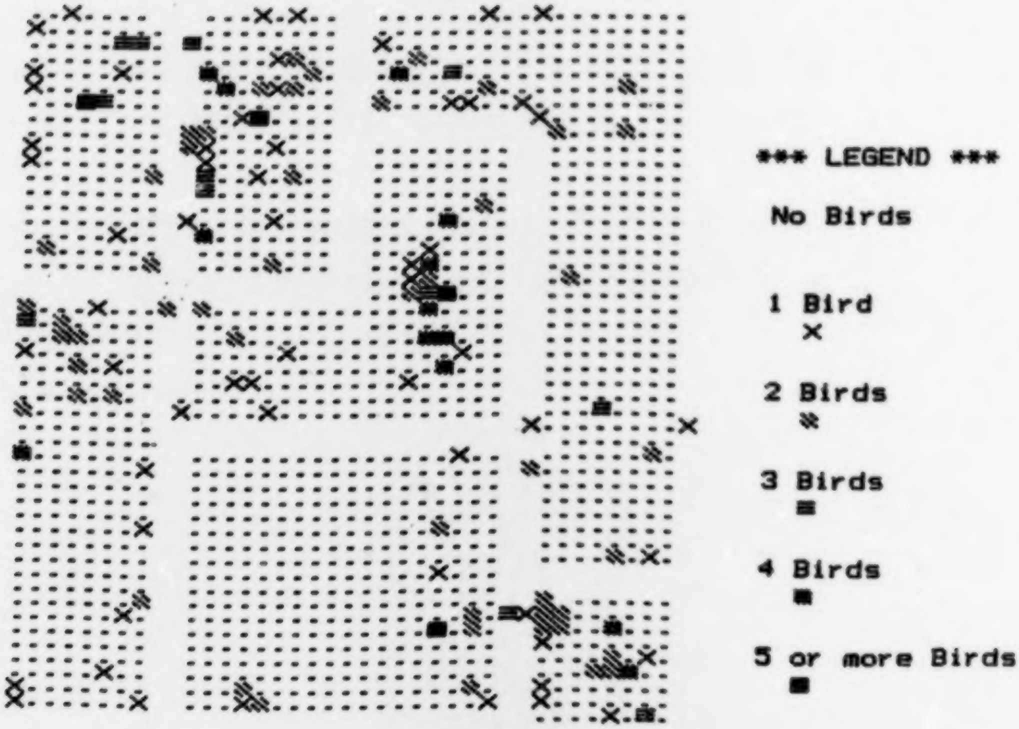

Figure 2.5: The distribution of all House Sparrows in the Parkview study area between 6 May and 23 July 1990. The map is based upon the total number of birds in each 10x10m cell. North is to the top of the page.

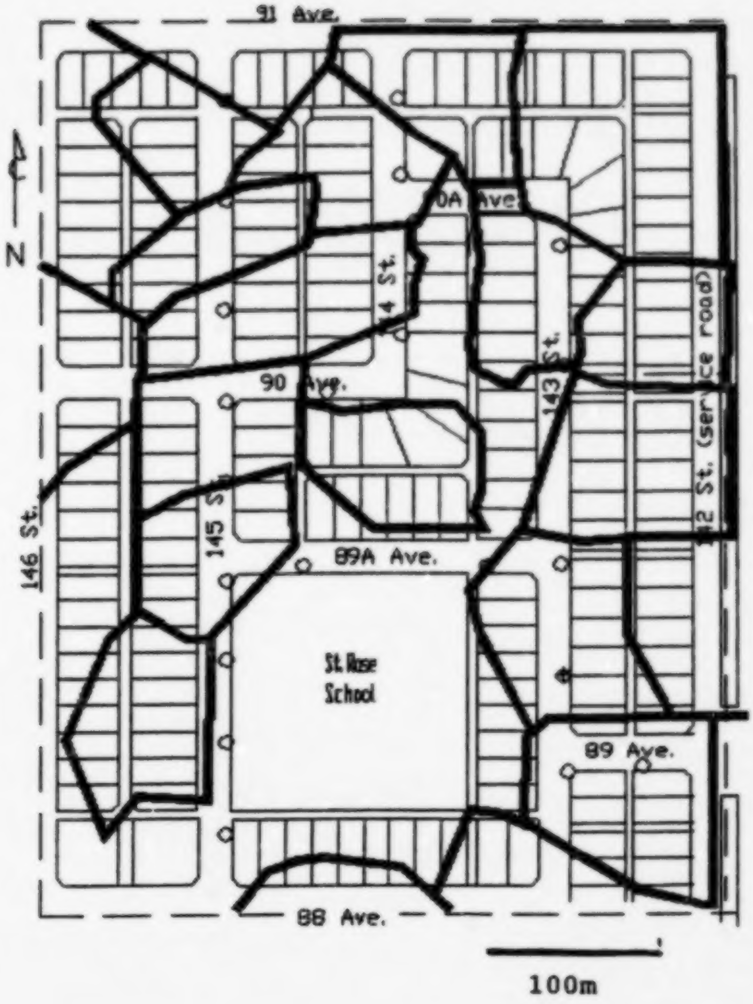

Figure 2.6: Approximate boundaries of the nesting territories erected and defended by breeding American Robins in the Parkview study area during the 1990 breeding season.

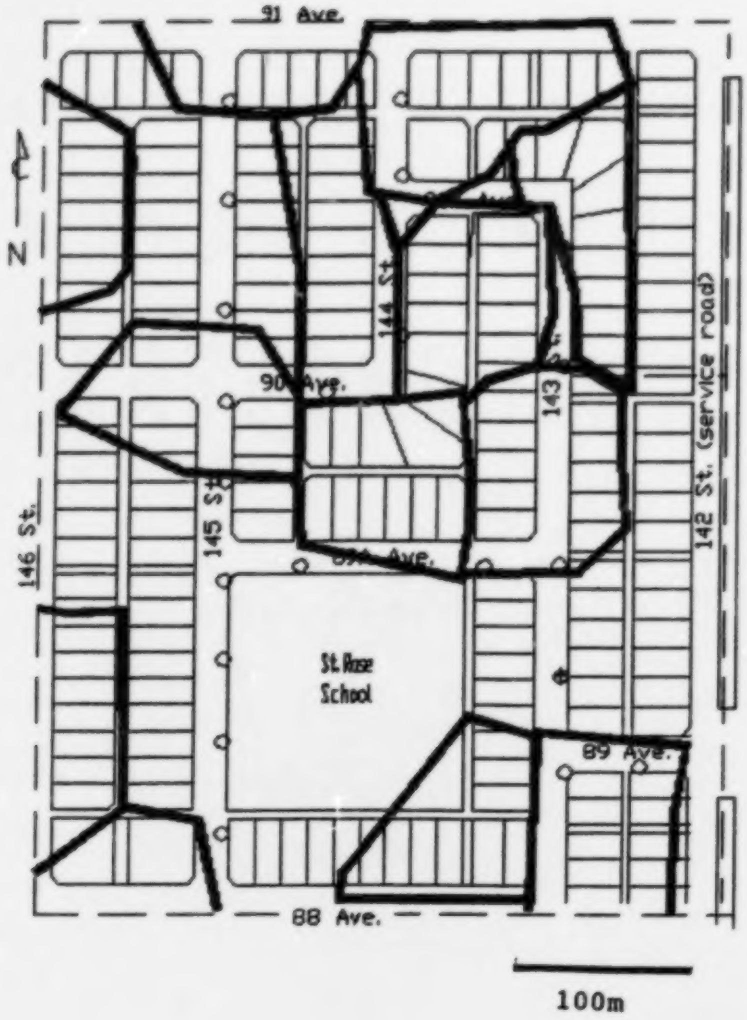

Figure 2.7: Approximate boundaries of the nesting territories erected and defended by breeding American Robins in the Parkview study area during the 1991 breeding season.

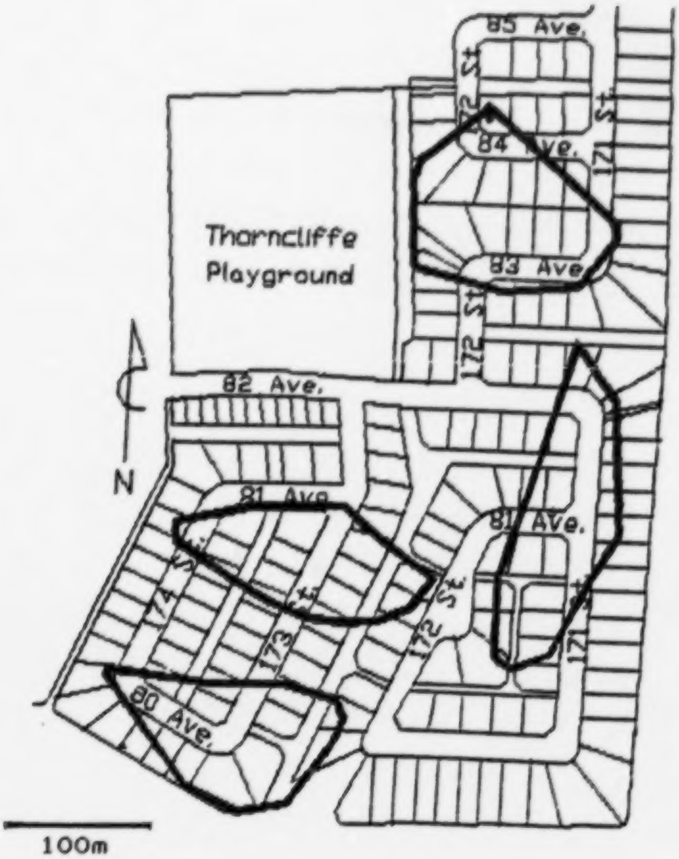

Figure 2.8: Approximate boundaries of the nesting territories erected and defended by breeding American Robins in the Thorncliffe study area during the 1990 breeding season.

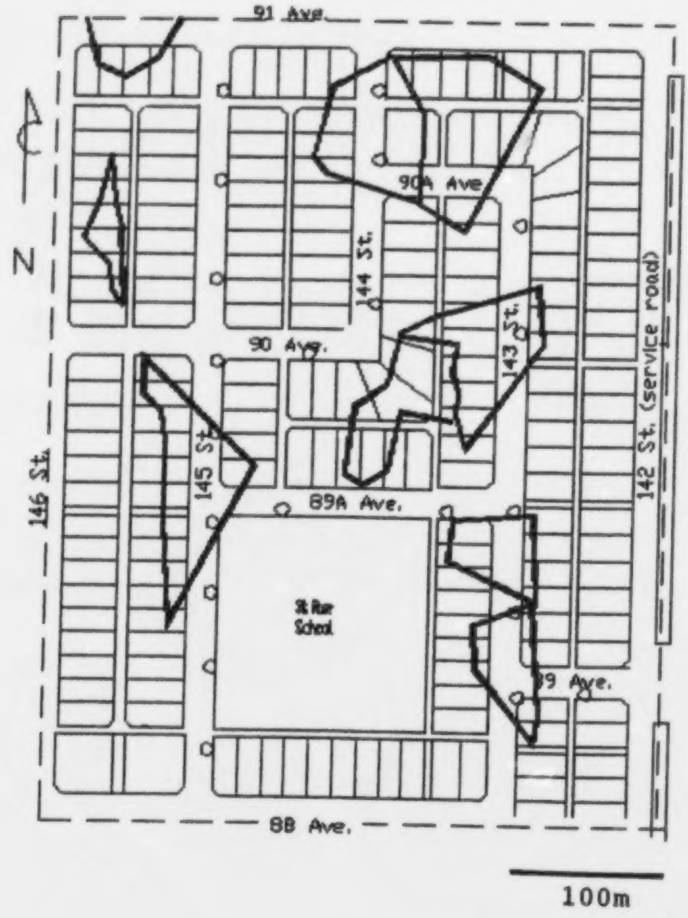

Figure 2.9: Approximate boundaries of the nesting territories erected and defended by breeding Chipping Sparrows in the Parkview study area during the 1990 breeding season.

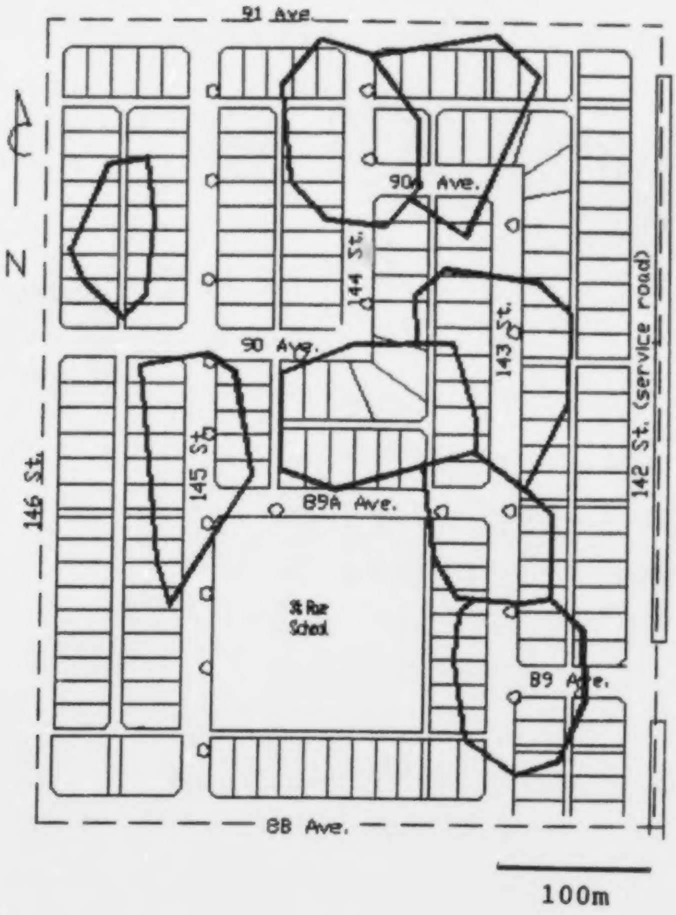

Figure 2.10: Approximate boundaries of the nesting territories erected and defended by breeding Chipping Sparrows in the Parkview study area during the 1991 breeding season.

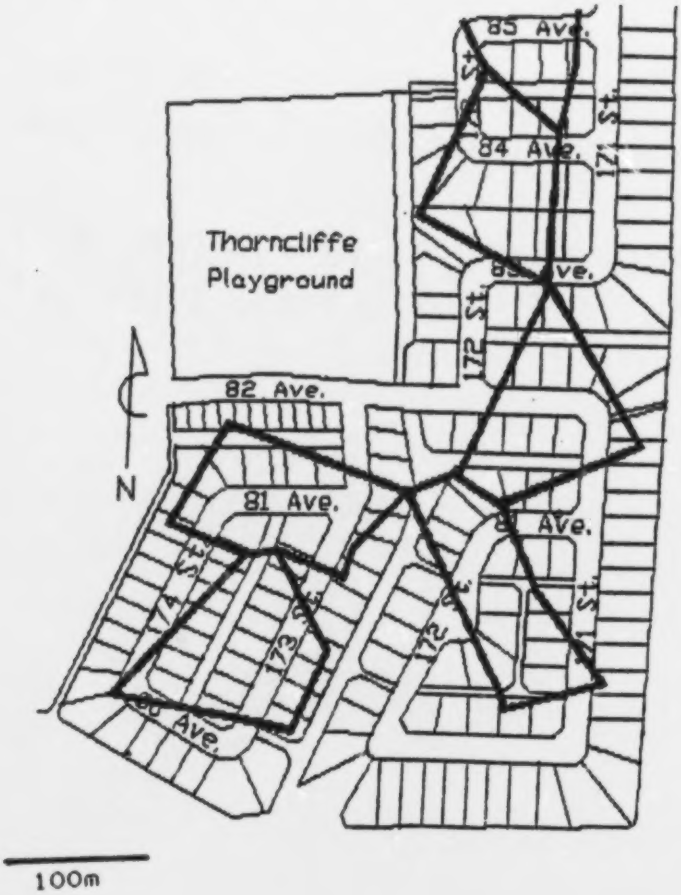

Figure 2.11: Approximate boundaries of the nesting territories erected and defended by breeding Chipping Sparrows in the Thorncliffe study area during the 1990 breeding season.

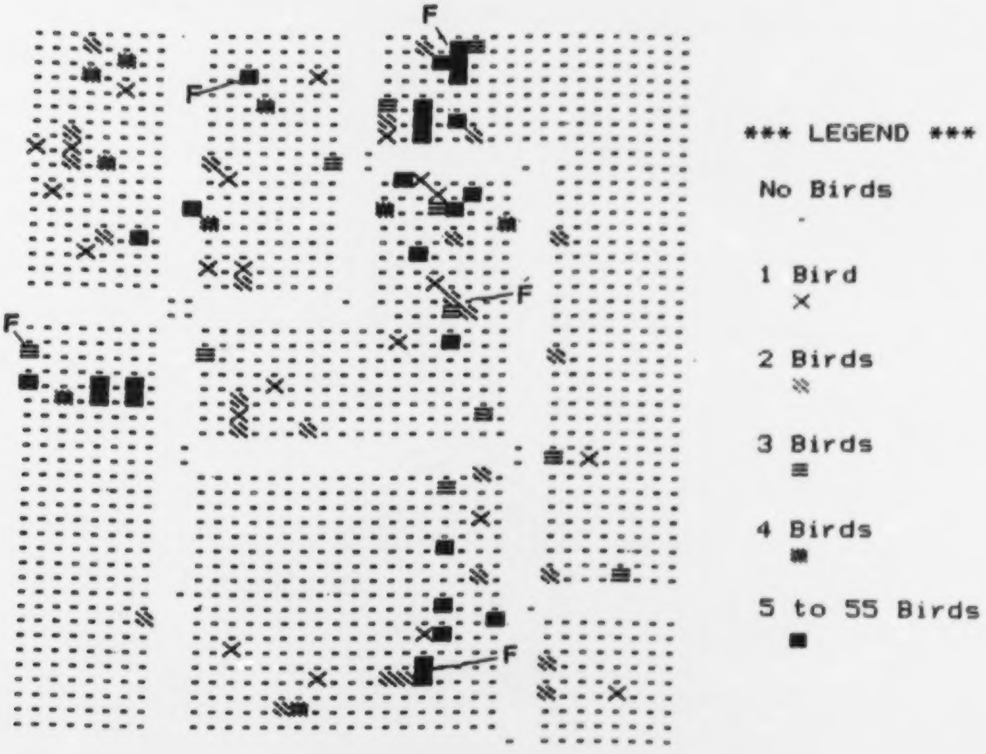

Figure 2.12: Distribution of flocking of House Sparrows in the Parkview study area during the post-breeding season (1 August to 7 November). The map is based upon the maximum number of birds counted in each 10mx10m cell. Feeders identified by the letter 'F'.

2.7 Tables

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean Temperature	-15	-9.6	-6	4.2	11.3	15.1	17.4	16.2	11	5.8	-3.7	-10.4
Precipitation	24.6	18.8	18.5	21.7	42.5	77.3	88.7	77.9	39.1	16.6	15.7	24.7

Table 2.1: Summary of climatic data for Edmonton based upon 30-year averages from 1951 to 1981. Temperatures in °C and precipitation in millimetres (Olsen 1985, Hare and Thomas 1979)

Factor	Parkview	Thorncliffe	LaPerle
Area (ha)	20	21	22
Edge (m/ha)	90	77.4	97.3
Length of Road (Km)	3.05	2.09	2.59
% area as Parks	10.99	14.86	8.14
# of properties	190	171	273
Distance from CBD*	5.4 Km	8.6 Km	9.4 Km
Age in years	35	20	10

*Central Business District

Table 2.2: Summary and comparison of physical structure of the three study areas.

Table 2.3:Results of the complete counts in each of the study areas, Parkview (a), Thorncliffe (b), and LaPerle(c). Results for the breeding, post-breeding, and winter seasons are separated by a solid line. Species names are those used by the A.O.U. (1983). Pd-*Passer domesticus*, Cc-*Cyanocitta cristata*, Pp-*Pica pica*, Pa-*Parus atricapillus*, Fc-*Falco columbarius*, Tm-*Turdus migratorius*, Jh-*Junco hyemalis*, Ld-*Larus delawarensis*, Sv-*Sturnus vulgarus*, Sp-*Spizella passerina*, Bc-*Bombycilla cedrorum*, Bg-*Bombycilla garrula*, Sc-*Sitta canadensis*, Cb-*Corvus brachyrynchos*, Sca-*Sitta carolinensis*, Cf-*Carduelis flammea*, Dp-*Dendroica petechia*, Ca-*Colaptes auratus*, Cp-*Carduelis pinus*, Ps-*Passerculus sandwichensis*.

Date	Week	Pd	Cc	Pp	Pa	Fc	Tm	Jh	Ld	Sv	Sp	Bc
06-May	3	53			2		15	1	4	1		
13-May	5	60		2	2		31	1		2	5	
20-May	6	64	3	1	4		24		4		11	
09-June	8	56	2	3	3		32		4		8	
07-July	14	48	2	5	1		10				14	
23-July	15	79	2	5	8		7				12	5
01-Aug	16	52	1	3	14		4				2	
08-Aug	17	99	5	6	11	1	4					
20-Aug	19	43	7	7	17		2		18			1
27-Aug	20	57	4		13		10					3
10-Sept	22	67	7	6	12		7		19			
21-Sept	23	51	3	4	4		2	14				
25-Sept	24	101	6	4	12		1	20	9			
12-Oct	26	91	3	4	4			17				
17-Oct	27	72	4	7	1			9		1		
28-Oct	29	104	3	2	3			1		1		
07-Nov	30	74	5	4	7					2		
14-Nov	31	78	2	1						1		
27-Nov	33	47	3	3	1							
07-Dec	34	69	6	10	7							
28-Dec	37	98	4	4	12	1						
12-Jan	39	90	3	6	4							
02-Feb	42	113	5	6	9							
20-Feb	45	51	3	5	2							
06-Mar	47	49	5	9								
12-Mar	48	80	1	9	2							
19-Mar	49	96	7	4	2							
26-Mar	50	65	6	4		1						
02-Apr	51	89	3	4	1		1					1
09-Apr	52	99	3	6		1	2	3	4			
Total		2193.00	108.00	136.00	158.00	4.00	152.00	66.00	62.00	8.00	52.00	10.00
Mean		73.10	3.60	4.53	5.27	0.13	5.07	2.20	2.07	0.27	1.73	0.33
Mean/km-1		365.50	18.00	22.67	26.33	0.67	25.33	11.00	10.33	1.33	8.67	1.67
Dominance		0.714	0.035	0.044	0.051	0.001	0.050	0.021	0.020	0.003	0.017	0.003

Table 2.3a: Parkview

Week #	Bg	Sc	Cb	Sca	Cf	Dp	Ca	Cp	Ps	Total #	H'
3										76	0.936
5										103	1.630
6						3				114	1.295
8										107	1.295
14										80	1.192
15										118	1.188
16									8	84	1.225
17									12	140	1.075
19									9	104	1.449
20						2				89	1.161
22		12				3				133	1.593
23										78	1.110
24										153	1.162
26										119	0.804
27			5	1						100	1.066
29										114	0.434
30										92	0.749
31								7		89	0.602
33		1								55	0.597
34		4			2					98	1.049
37				1			1			121	0.744
39		2					1			106	0.645
42	8	3								144	0.677
45					1					62	0.688
47	4				2					69	0.791
48	3				1					96	0.636
49	22				2					132	0.568
50					1					77	0.606
51										99	0.471
52										118	0.710
	37.00	22.00	5.00	2.00	9.00	8.00	2.00	7.00	29.00	3070	-
	1.23	0.73	0.17	0.07	0.30	0.27	0.07	0.23	0.97	102.3333	0.93096
	6.17	3.67	0.83	0.33	1.50	1.33	0.33	1.17	4.83	511.67	-
	1.276	0.007	0.002	0.001	0.003	0.003	0.001	0.002	0.009	-	-

Table 2.3a: Continued

Date	Week #	Pd	Cc	Pp	Pa	Fc	Tm	Jd	Ld	Sv	Sp	Bc
05-May	3	34		2			10			4		
21-May	6	29					7				13	
03-Jun	8	47					9				16	
24-Jul	15	29	1				3		1		10	1
09-Aug	17	95		6	1				7		1	
28-Aug	20	8	2				2				20	
13-Sep	22	75	7	6	4	1	3	2	1			
29-Sep	24	52	3	4				7	6			
22-Oct	28	72	7	5	1				2	7		
14-Dec	35	8	1	2	1							
09-Feb	43	69										
09-Mar	47	70										
30-Mar	50	41										
Total		629	21	25	7	1	34	9	17	11	60	1
Mean		48.38	1.62	1.92	0.54	0.08	2.62	0.69	1.31	0.85	4.62	0.08
Mean/km-1		230.41	7.69	9.16	2.56	0.37	12.45	3.30	6.23	4.03	21.98	0.37
Dominance		76.80%	2.56%	3.05%	0.85%	0.12%	4.15%	1.10%	2.08%	1.34%	7.33%	0.12%

Table 2.3b: Thorncliffe

Week #	Bg	Sc	Cb	Sca	Cf	Dp	Ca	Cp	Ps	Total	H'
3										53	0.915
6										55	0.940
8										80	0.873
15										60	1.052
17			1							128	0.593
20										52	0.967
22			3							124	1.079
24										96	0.801
28										122	0.721
36										47	0.684
43										112	0.000
47										117	0.000
50										91	0.000
Total	0	0	4	0	0	0	0	0	0	819	
Mean	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	63	
Mean/km-1	0.00	0.00	1.47	0.00	0.00	0.00	0.00	0.00	0.00	300.006	
Dominance	0.00%	0.00%	0.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	

Table 2.3b: Continued

Date	Week #	Pd	Cc	Pp	Pa	Fc	Tm	Jh	Ld	Sv	Sp	Bc
12 May	4	13										
18 May	5	0										
27 May	7	9									1	
03 Aug	16	4									2	
21 Aug	19	2									3	
11 Nov	31	4										
04 Jan	38	4										
03 Feb	43	1										
24 Feb	46	3										
Total	Total	40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.00	0.00
Mean	Mean	4.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00
Mean/Km-1	Mean/Km-	20.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.03	0.00
Dominance	Dominanc	86.96%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.04%	0.00%

Table 2.3c: LaPerle

Table 2.3c: Continued

Week #	Bg	Sc	Sca	Cf	Dp	Ca	Cp	Ps	Total
4									17
5									5
7									17
16									22
19									24
31									36
38									42
43									44
46									49
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.111111
Mean/Km-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.23232
Dominanc	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%

	Parkview		Thorncliffe	
Feature	Number	%	Number	%
Conifers >6m	44	62	5	33.3
Power lines	16	22.5	0	0.0
Birch	6	8.5	3	20
Maple	2	2.8	5	33.3
Elm	1	1.4	0	0.0
Willow	1	1.4	0	0.0
Mountain Ash	1	1.4	0	0.0
Apple	0	0.0	1	6.7
Mayday	0	0.0	1	6.7
Total	71	100	15	100

Table 2.4: Habitat features used as singing posts by singing male Robins in the Parkview and Thorncliffe study areas during the 1990 breeding season.

	Parkview		Thorncliffe	
	Number	%	Number	%
Conifers	12	44.4	10	31.2
Birch	5	18.5	13	40.6
Maple	3	11.2	3	9.4
Power Lines	2	7.4	0	0.0
Poplar	2	7.4	1	3.1
Mountain As	1	3.7	0	0.0
Mayday	2	7.4	1	3.1
Willow	0	0.0	2	6.3
Apple	0	0.0	2	6.3
Total	27	100.0	32	100.0

Table 2.5: Habitat features used by singing male Chipping Sparrows in the Parkview and Thorncliffe study areas during the 1990 breeding season.

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3. Habitat Structure in Three Residential Communities in Edmonton, Alberta and Some Impacts on the Bird Population.

3.1 Introduction

The increase in urbanization since World War II coupled with a growing public awareness for the environment has stimulated research in urban wildlife. The majority of these urban studies focus on birds since they are numerous, highly visible, and audible. In Canada, this includes a number of studies of breeding birds (Erskine, 1970 and 1972; Speirs et al., 1970; Weber, 1975) and of winter bird populations (Erskine 1974; Spencer 1973). The principal concern of these studies was to catalogue the species present within the study areas and there was little attempt to relate the distribution of the birds to habitat features within the urban environment. Campbell and Dagg (1976) studied the wintering and breeding bird populations on 5 plots in Kitchener-Waterloo, Ontario and used these data to describe a generalized urban-rural gradient. Along this gradient they found that the diversity decreased with an increase in the number of buildings while the density increased with an increase in the number of trees. Correlations with habitat features were not quantified in this study.

In general, the areas studied had a milder climate, different native tree cover, and were urbanized to a different extent than Edmonton. In addition, these studies did not include sufficiently detailed descriptions of the structure of the urban habitat for comparison to that of Edmonton. Beyond generalities, their physical environments differ greatly from Edmonton and this limitation restricts their usefulness in comparing habitat associations of urban birds. Many studies, such as Weber (1975) evaluate the habitat by estimation of percent coverage for various tree types and this is also a common practise in breeding bird and winter bird censuses published by American Birds. Other studies, such as Savard (1978), made accurate inventories of the habitat in small blocks and extrapolated the data to the full study area. This practise presumes a uniformity of habitat which may or may not be real.

This study describes and compares the structure of the urban tree cover in three residential communities, spanning 35 years, within Edmonton. Other habitat features, such as tree clumps and bird feeders, which appear to influence urban birds, are also examined.

3.2 Study Areas

Three study areas were selected in west Edmonton (Figure 2.1) as being representative of different degrees of development (e.g. size, cover and species diversity) in the tree cover, along a gradient within residential districts from near the city centre to the urban fringe. The areas of Parkview (Figure 2.2), Thorncliffe (Figure 2.3), and Laperle (Figure 2.4) were typical of residential suburbs 35, 20, and 10 years old, respectively. Each of the study areas were free of extensive re-development and they were structurally similar (Table 2.2), with approximately the same length of roads and alleyways, open space, and the areas contain only single family dwellings. The three study areas were fully described in Edgar (1992, Part 2).

3.3 Methods

In order to determine the composition, distribution, and height of the trees within the three study areas, the trees were mapped and the data were recorded on 1:5000 cadastral maps. The composition of the tree cover to the genus level together with the number of trees in each of four height classes were summarized for the study areas. Four height classes were determined to best describe the vertical distribution of the trees within the study areas. The limits defining the height classes were selected as they reflected the maximum height of mature trees (Knowles, 1989). Conifers and birch attain heights in excess of 9m (Class 4). Ash, some forms of birch, and maple attain a height between 6m and 9m (Class 3), fruit-bearing trees, such as crabapple and plum, and some maple range from 3m to 6m at maturity (Class 2).

Newly planted trees are often purchased from commercial greenhouses and nurseries and are generally less than 3m (Class 1).

In order to generalize the tree data, the study areas, were sub-divided into 10x10m cells for mapping purposes. Computer software was written to produce a series of maps to depict the distribution of trees by height and by genus. The height distribution maps depict the height of the tallest tree within each 10x10m cell. The distribution of tree genera were shown by mode for each cell. In order to generalize the distribution of genera, the field data were divided into 5 classes. These were:

1) Conifers: a) Spruce (*Picea*)
    b) Pine (*Pinus*)
2) Birch (*Betula*)
3) fruit-bearing trees: a) Apple (*Malus*)
    b) Mountain Ash (*Sorbus*)
    c) Mayday (*Prunus*)

4) long-winged seed trees: a) Maple (*Acer*)
    b) Alder (*Alnus*)
5) miscellaneous: a) Poplar (*Populus*)
    b) Elm (*Ulmus*)
    c) Willow (*Salix*)
    d) Oak (*Quercus*)

A Kruskal-Wallis H-test was used to test for differences in the tree cover between the three study areas. The H-test used the following relationships:

$$H= 12/n(n+1) *(T1^2/n1+T2^2/n2+T3^2/n3)-3(n+1) \qquad [1]$$

Where:

n1,n2,n3 = number of replicates in the samples.

n = n1+n2+n3

T1, T2, T3 = rank sum of the samples.

3.4 Results

3.4.1 Habitat Description

In the younger area, LaPerle, 86% of the trees fell included within height class 1 (Figure 3.1). This group included the younger trees and the slower-growing species such as spruce (Picea spp.), birch (Betula spp.), and mountain ash (Sorbus spp.) trees. The trees belonging to height class 4 were generally represented by faster growing species as well as some which appeared to be remnants of the original tree cover. This class had the lowest number of individuals and included maple (Acer spp.), poplar (Populus spp.), and willow (Salix spp.).

Thorncliffe, the intermediate aged area, had a greater number of trees (67%) included in height classes 2 and 3 (Figure 3.1). There was a concomitant decrease in the number of shorter specimens. This shift towards the central height classes primarily reflects the longer period of time since the planting of ornamental trees and shrubs after development of this 20-year-old residential area. With 31% of the ornamentals in height Class 1 approximately 15 years after development began, it indicates that landscaping by individual homeowners continues.

The oldest of the study areas, Parkview, contrasts with the younger subdivisions in that 30% of its ornamental tree cover exceeded 9m (Figure 3.1). The small number of trees in height class 1 was largely the result of the planting of younger trees as replacements for larger, older trees.

Considering the 3 study areas it was evident that the composition of the ornamental woody plant cover shifted from short to progressively taller individuals as one moved from the youngest to oldest subdivision (Table 3.1). A 3x4 contingency table was used to test the hypothesis that there was no significant difference in the distribution between the height classes of the trees in each of the study areas. The resulting calculated Chi-square (1272.4) was greater than the critical Chi-square of 12.59 (df=6, α=0.05). Based on this result, the null hypothesis was rejected and it was concluded that there were significant differences in the distribution of the trees among the height classes.

Of the total of 12 tree genera, 10 were found in all three study areas (Table 3.1). Spruce was the dominant genus in the urban environment, totalling between 50 and 60% of the trees selected by urban dwellers in all 3 subdivisions (Figure 3.2). To test the hypothesis that floristic composition of the tree cover was not different in each of the three study areas, a 3x5 contingency table was applied to the dataset. The calculated Chi-square (14.96) was less than the critical Chi-square of 15.51 (df=8, α=0.05). Based on this result, the null hypothesis was rejected and it was concluded that the species composition of the tree cover did not vary significantly among the three study areas.

Birch declined from approximately 16% of the ornamentals in the 35-year-old subdivision to 12% in the 10-year-old residential development. This decline may be a reflection in the frustration many urban homeowners experience when dealing with infestations of sawfly larvae. This particular species composed approximately 16% of the ornamental trees in the oldest study area; approximately 17% in the Thorncliffe area and about 12% in the youngest of the study areas (Figure 3.2, Table 3.1).

As a group, fruit bearing trees varied considerably between the three study areas. This group accounted for 20.78% of the trees in the older study area; 12.36% in the younger Thorncliffe area and 19.8% of the trees in the youngest study area, LaPerle. Trees with winged seeds, Class 4, composed approximately 8.63% of the total tree population in the oldest study area, rose to greater than 12%

in the intermediate-aged study area and declined to near 6.4% in the youngest study area, LaPerle.

Class 5 included miscellaneous tree genera which were apparent only in relatively small numbers, generally 2% or less of the total population. Within this group, only the poplars have increased in popularity with urban landscapers, rising from 1.46% in the oldest study area to 6.35% in the youngest of the study areas. This may reflect the fact that these trees are generally short-lived, rapid growing plants that as they senesce are prone to breakage and may be removed by residents wishing to reduce the potential for property damage.

Despite the differences in age among the 3 study areas - one built in the mid-1950's, one in the early-1970's and one in the mid-1980's, the species of ornamental trees selected for landscaping by urban dwellers have remained similar (Figure 3.2).

3.4.2 Relationship between abundance of birds and age of the study areas

In all seasons, Edgar (1992, Part 2) the oldest study area had the greatest diversity and density of species (511.5 individuals km^{-2}). The younger Thorncliffe area had a lower average diversity (0.665) and density (300 individual km^{-2}) in all seasons. The youngest study area, LaPerle, had the lowest density (5.11 individuals km^{-2}). The age of the study areas was reflected in the distribution of the tree cover among the 4 height classes (Figure 3.1). Thus, there was a gradient in diversity and density from the older to the youngest of the study areas.

3.4.3 Impact of tree clumps

In the Parkview study area, there was an apparent increase in the number of birds seen in clumps of coniferous trees. To determine whether these observations were real, all clumps of coniferous trees were identified. For the purposes of analysis, a clump was defined as a 30x30 m block which contained a minimum of 8 trees belonging to the same genus. The average number of birds at each of these locations was tabulated for each season (Table 3.2). As a control, similar data were compiled for 10 randomly selected sites within the study area (Table 3.3). A Kruskal-Wallis H-test was used to test the hypothesis that the number of birds seen in tree clumps was greater than the number of birds seen in the control areas. The calculated H statistic of 1.84 was less than the critical value for a Chi-square distribution (3.84, $df=2$, $\alpha=0.05$). Based upon these results the null hypothesis was rejected and it was concluded that there was not a significant difference in the number of birds associated with clumps of trees compared to the control areas.

3.4.4 Bird density in open spaces

In each of the study areas there was a large tract of open land which served a dual purpose as schoolyard and recreation area. The open space in Parkview was covered in close cropped grasses and devoid of woody plant material. In the two younger study areas, there were some small, stunted trees along the margin of the open spaces, however, they were dominated by short cropped grasses (Figure 3.4, 3.6 and 3.8).

Only two species of birds were observed in these areas; magpies (*Pica pica*) and Ring-billed Gulls (*Larus delawarensis*).

These species had an average density per survey of 1.3 birds, 0.46 individuals ha^{-2} per survey, while no birds were seen in the open area in LaPerle.

3.4.5 Inhospitable habitat

During the course of the field observations, there appeared to be proportionally fewer birds counted along the eastern margin of the Parkview study area. To determine whether these observations along 142 St. were significant, two 50x500 m blocks were defined and compared with data for the whole study area. The first block (Block I) included the 50x500 m area adjacent to 142 St. Block II was defined as the 50x500 m block on the west side of 143 St. The long axis for both blocks faced east and they were structurally similar.

The habitat features were tabulated (Table 3.4) from the database which was used to construct the maps in Figures 3.3 and 3.4. A 3x5 contingency table was used to test the hypothesis that the distribution of trees in Block I, and Block II, among the 5 type classes differed from that of the whole Parkview study area. It was found that the Chi-square (8.94) was less than the expected Chi-square of 15.51 (df=8, α=0.05), therefore the null hypothesis was rejected and it was concluded that the distribution of the trees among the 5 height classes was the same for the 3 areas. A 3x4 contingency table was used to test the hypothesis that the distribution of the trees, in Block I and Block II, among the height classes was different from the whole Parkview study area. It was found that the calculated Chi-square (7.595) was less than the expected Chi-square of 12.59 (df=6, α=0.05) and the null hypothesis was rejected. Consequently, it was concluded that the distribution of trees between the height classes and the type classes of the samples were not significantly different from that found in the complete 20ha study area.

The number of jays, chickadees, Chipping Sparrows, and robins were counted in each of the 2 blocks. House Sparrows were excluded since their distribution is influenced by the location of bird feeders which are constantly stocked with seed (Edgar 1992, Part 2). There were, in each block, a number of feeders which were stocked with seed on an irregular basis.

Each season was tabulated separately (Table 3.5). On an annual basis, it was found that 47 birds were counted in Block I and 104 birds were counted in Block II. To test the hypothesis that the number of birds observed within Block I was not significantly different from the number of birds observed in Block II, a Chi-square test was used. The result for Block I (9.01) was greater than the expected Chi-square of 3.84 ($df=1$, $\alpha=0.05$), therefore, the hypothesis was rejected. Thus, it was concluded that there was a significant difference in the number of birds counted within the two areas.

3.5 Discussion

The types of trees planted over the past 35 years did not vary significantly between the three study areas. It was found, however, that there was a considerable difference in the density of the tree cover. The LaPerle area had less than one-half the tree density in the two older study areas. The reasons for this difference are not known. The height of the trees was also found to vary significantly between the three study areas and the difference in height was primarily attributed to senescence. As a result of this difference there was a gradient in tree height from the tallest in the older Parkview area to the shortest in the newest subdivision of LaPerle near the city's outskirts.

3.5.1 Arboreal Habitat - Cover

Urbanization has resulted in the formation of an arboreal island in the sense that the physiognomy of the tree cover is distinctly different from the native tree cover found in surrounding rural woodland areas. In the urban environment locally native species, such as Trembling Aspen (Populus tremuloides), were a minor component of the tree cover. The city, which acts as an arboreal island possesses a number of distinct characteristics which result from the unnatural spacing, association, and controlled canopy character of exotic and hybrid tree species (Figures 3.3 to 3.8). These characteristics result in an urban habitat which lacks the natural species associations and height characteristics of habitats found in wildlands.

The urban environment is an agglomeration of privately held individual properties, each with its own characteristic micro-habitat determined by the trees planted by property owners and by their individual property management methods. This individualism has resulted in discontinuities in lateral distribution; variation in the distance between individual trees and the planting of tree species in unnatural associations. Wide variation in tree height over relatively short distances, was also apparent. These discontinuities are the result of planting different tree genera on neighbouring properties and from variations in factors which affect growth, such as the rate of application of water and fertilizer.

Fraser (1962) has shown that low soil moisture inhibits tree growth and that very low soil water levels can cause tree growth to cease. Kawana et al (1988) demonstrated that slow-release fertilizers can significantly increase growth rates in trees. Individual landowners on adjacent properties may employ different yard maintenance practices that reinforce differences in tree cover for suburban avifauna. There is also a tendency to plant tall-growing, ornamental tree varieties in the front yards of properties.

As a consequence of these actions, the tree canopy was not uniform in either height or tree-type and this appears to have become a limiting factor in the distribution of canopy-dwelling birds, such as orioles. Orioles are birds of the upper-canopy and seldom descend to the shrub layer (Salt and Wilk, 1966).

There is a tendency for urban dwellers to remove trees which have become, as a result of growth or changing landscape priorities dictated by fashion, less than aesthetically ideal. As trees mature they become subject to disease and infestations which result in the creation of cavities within the trunk and limbs. Such cavities are apparently considered a sign of weakness in the structural integrity of mature trees with a consequent rise in the perception of danger to both structures and people. There is also a very real probability that growing trees may interfere with urban structures such as buildings and overhead service lines. Very often, the interference with buildings and overhead electrical services results from the inappropriate planting of trees too close to structures and there is a legion of anecdotal stories describing damage, by tree roots, to foundations and underground services, such as water pipes. All these forces can result in the selective removal of mature trees. From April 1990 to April 1991, 5 large mature trees were removed from the Parkview study area. Of these trees, a 20m poplar was removed since it was believed to be "too close to the power lines"; a 12m birch was removed because "it was dying";a mature Manitoba Maple was removed because "it was taking over the yard". The other two trees, a mature willow and a mature Manitoba Maple, were removed for unknown reasons. In addition to increasing the discontinuity of the canopy, these extractions result in the loss of potential nesting and roosting sites for cavity-dwelling birds such as picids, sittids, and parids.

3.5.2 Arboreal Habitat - insectivores

Fashion is seldom considered a force in urban environments, however, it does influence the types of trees selected for planting in urban areas. Birch trees, which are a common ornamental in residential areas dating from the 1950's and 1960's (Figure 3.2), are subject to infestation by burrowing larvae of three species of sawfly (Fenusa pusilla, Heterarthus nemoratus, Profenusa thomsoni) (Drouin and Wong, 1984). While these insects do not seriously harm the trees, they do cause serious degradation in the aesthetic quality of the tree. Edgar (1992, Part 4) suggested a relationship between the emergence of the sawfly larvae and the distribution of migrating Savannah Sparrows. This association with birch trees may explain why Savannah Sparrows were commonly observed in the older Parkview study area which contained a large number of mature birch trees, but not in the two younger study areas.

Contemporaneously, the increased numbers of Chipping Sparrows observed in the Thorncliffe study (Edgar 1992, Part 2) suggests that this habitat was more frequently selected by to migrating Chipping Sparrows than the mature habitats found within Parkview. The LaPerle site was the least selected by to Chipping Sparrows, as their relative absence for the area suggests.

3.5.3 Arboreal Habitat - fruit availability

Waxwings are irruptive in their winter distribution (Root, 1988) and, as a consequence, numbers vary considerably from year to year. In the winter season, the distribution of the Bohemian Waxwings (*Bombycilla garrula*) and the Cedar Waxwings (*B. cedrorum*) was related to the distribution of mature Mountain Ash trees (*Sorbus* spp.) and crabapple trees (*Malus* spp.) which are a favoured winter food resource (Edgar 1992, Part 2). Large numbers of Bohemian Waxwings were seen in the area surrounding the Parkview study area, but not during censuses. The occurrence of waxwings appears to be related to the number of mature Mountain Ash trees, however, it is difficult to provide conclusive data since the species was only seen in the older Parkview study area.

3.5.4 Open Space Habitat

The distribution of open spaces within the study areas also has an impact on the distribution of birds just as the distribution of trees exerts pressure on the bird assemblage. Ring-billed Gulls, which were noted in both the Parkview and Thorncliffe study areas during the spring and fall migration periods, occurred in small numbers (1.3 and 0.46 birds per survey) and appear to be influenced in their distribution by urbanization. These birds were found in open parks and schoolyards (Figure 2.2 and 2.3). It would not be surprising to see adult birds in open areas early in the breeding season, neither would it be surprising to see non-breeding juveniles. It is, however, surprising to see only adult-coloured birds (Peterson, 1990) in the city during the peak of the breeding season. Based on casual observation, gulls sighted in open areas early in the season appeared to be paired. Gulls observed throughout April and May do exhibit breeding behaviour such as displaying and other interactions between individuals, but, there is no evidence to suggest that these birds were actually breeding. Vermeer (1970) showed that

Ring-billed Gulls initiate their clutches in early May with the average date being 10 May. Thus the reason for their occurrence in the Parkview study area until 9 June 1990, well beyond the expected date for clutch initiation, cannot be explained. Further inquiry would necessitate the use of marked birds to follow the behaviour of individuals and some dissections would likely be required to establish the sex ratios of the population and the breeding status of individuals. Only overflying gulls were sighted in the Laperle area, thus, they were not included in the data. During the fall migration Ring-billed Gulls appear in larger flocks than appears common in the spring population. In addition to their appearance in the parks and schoolyards of the Parkview and Thorncliffe study areas, casual observations (5 November 1990) in river valley areas revealed flocks of Ring-billed Gulls numbering in the hundreds.

3.5.5 Inhospitable Habitat

The habitat along the eastern margin was not found to vary substantively from that found in the balance of the study area. In the Parkview area, an analysis of a 50x500 m block along the eastern margin which adjoins 142 St. showed that the relative abundance of birds was significantly less than the abundance of birds in a similar area located 100m to the west. The number of birds seen, in all seasons 19.8 birds ha^{-1} compared to 45.4 birds ha^{-1}. in the control area. This trend, of diminished occurrence, was noted in all seasons (Table 3.5). The only species which appeared to be unaffected by the noise was the American Robin. This species occurred with nearly equal frequency in both blocks; 21 birds versus 20 birds in the control block. The robin was the only species which was confirmed to be nesting in the sample block. A number of natural environmental factors may account for the variation in the number of birds seen in Block I and Block II, including availability of food resources or the presence of predators. There are no data or observations which either indicate or exclude the impact of such factors on the differences in relative abundance between Block I and Block II.

A noise study conducted by Alberta Environment (1973) found that noise levels along the eastern margin (142 St.) of the study area ranged between 57 and 69 decibels. The same study found, on the western margin of the subdivision (149 St.), that sound levels 15m from the street ranged between 56 and 72 Decibels and these levels declined to between 53 and 56 Decibels at a distance of 50m. Noise from roadways, with high traffic flow, might have had an impact on the relative abundance of birds along the eastern margin of the Parkview study area. Campbell and Dagg (1976) noted a lower number of birds in areas with high noise, but, do not quantify their observations. It is recognized that the simple availability of data does not connote a cause and effect relationship, however these results are highly suggestive. The relationship between noise and bird densities is offered as a speculation which could form the basis for further investigation.

3.5.6 Tree clumps

In the oldest study area, a comparison between the number of birds associated with clumps of coniferous trees and the number of birds associated with 10 randomly selected control areas indicated that tree clumps were not a significant habitat feature for either exotic or native bird species.

3.6 Long-term enhancement of urban environment

In the long-term, planners, landscape architects, and builders should be encouraged to leave tracts of naturally forested land as parkland in order to attract and retain a more diverse assemblage of birds, such as that described by Flack (1976). As a group and as individuals, these people have the greatest degree of control in determining the extent of habitat alteration (Grey and Deneke, 1986) which results from urbanization. Their actions could result in the retention of habitats which provide nesting and roosting sites for indigenous birds and would probably serve to attract birds into newly developed subdivisions. The City of Edmonton has no policy in this area whatsoever.

In new subdivisions, residents could be encouraged to plant rapidly growing trees, such as poplar, mayday and Manitoba Maple (Knowles, 1989), in addition to the slower growing spruce and birch trees. Planting fast-growing species among slower-growing provides a means of mimicking forest succession and may prove attractive to some species (Hough 1984). There is also a distinct role for the city to provide accurate growing and planting information to new residents through existing facilities, such as the John Janzen Nature Centre and the Muttart Conservatory. Such facilities could work in concert with sellers and buyers of new homes by offering advice and literature to assist in the selection and care of plants suitable for urban areas. It is even possible that city governments might provide some form of tax incentive for residents who plant rapidly growing tree species or trees which exceed certain size limits.

3.7 Implications for urban environmental enhancement for avifauna - homeowners

In the short-term, residents can significantly affect patterns of distribution by providing urban birds with access to food, water, and nesting sites. In this study, the greatest density in bird populations occurred in and about bird feeders in the Thorncliffe and Parkview study areas in all seasons. However, these are established areas with a more or less developed tree cover and the role of habitat cannot be overlooked. In spite of this circumstance, access to a consistent food resource is requisite to the survival urban birds and this is especially true in winter (Gill 1989). A number of guides to bird feeding are available, but some, such as Waldon (1990), are directed at feeders being used on the Canadian prairies.

Urban areas tend to have little standing water and this is as necessary to birds as it is to humans. There are anecdotal observations which suggest that the erection of a bird bath can influence the territorial boundaries of nesting birds, such as robins.

Artificial nesting sites are important if birds are to be induced to remain within an area over the long-term. Proper construction and siting is necessary if particular species are to be attracted. In satisfying these short-term goals, there is a role for city agencies such as the nature centres. It is, however, imperative that these agencies disseminate information which is relevant and applicable to urban areas with similar climatic regimes as well as similar assemblages of birds.

3.8 Conclusions

The surveys of the tree cover within the three study areas showed that the types of trees planted by residential landowners had not changed significantly since the mid-1950's.

Ten of twelve tree genera occurred in all three study areas. The only significant difference between the tree cover in the three study areas was the difference in height. On this basis a gradient was defined from the oldest area, Parkview, which had the tallest trees to the youngest study area, LaPerle, which had the smallest trees. The trees in Thorncliffe were of an intermediate height. The difference in height was attributed to senescence. No other case study, which could be compared against the results of this study, could be found in the literature. No studies of the urban tree cover could be found for the prairies of western Canada.

While remarkably uniform in physiognomy, variation in habitat quality for birds was apparent. A gradient in bird population density was defined and was related to the number of coniferous trees in excess of 6m in height. Open spaces, with their close cropped grass and lack of tree cover, afforded few habitat resources for birds. Such areas were used principally as loafing areas by gulls and foraging areas by magpies. Areas along the major transportation route, which formed the eastern boundary of the oldest study area, also supported significantly fewer birds when compared with a control area within the subdivision. Reason for the disparity in relative abundance are not known absolutely, but, it was speculated that noise was a possible cause.

The Laperle and Thorncliffe study areas afford an ideal opportunity for long-term studies into the effect of a developing tree cover on the composition and evolution of urban bird communities.

3.9 Figures

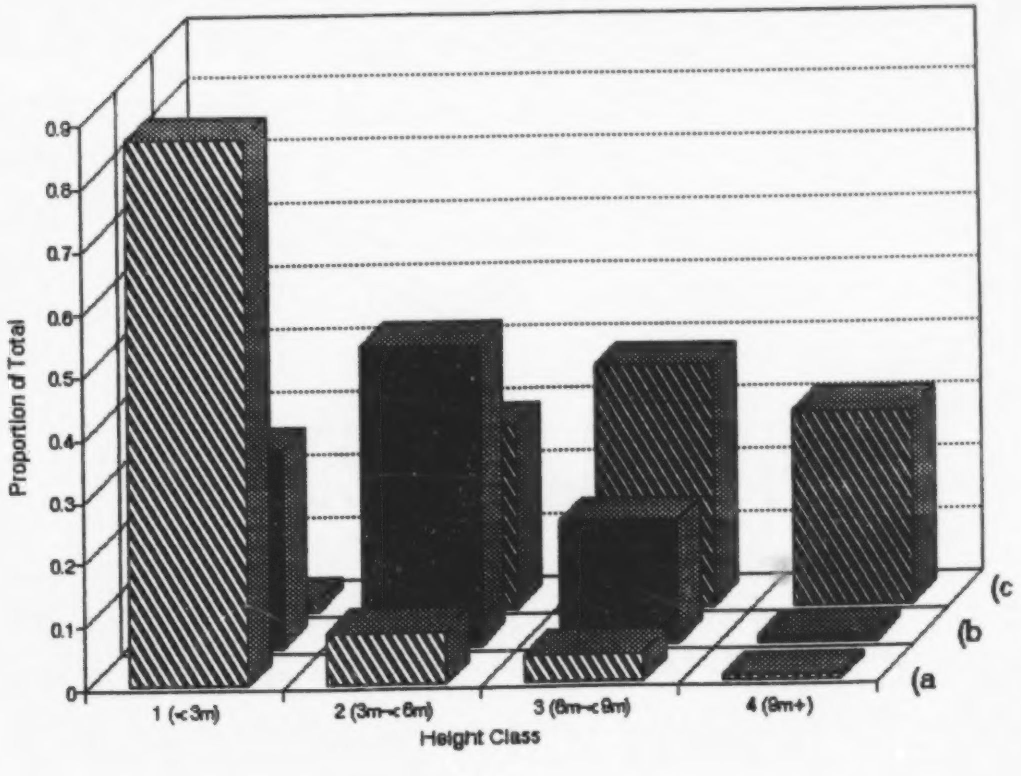

Figure 3.1: Comparison of the tree height in the three study areas. a) LaPerle, b) Thorncliffe, c) Parkview.

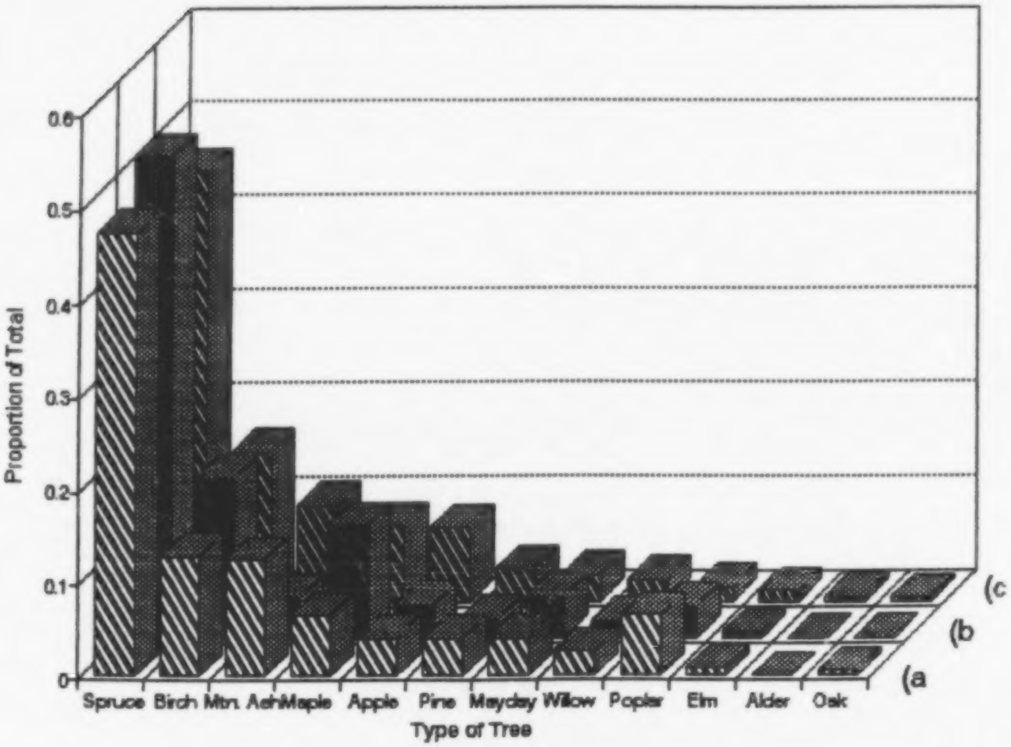

Figure 3.2: Comparison of the dominance of the tree varieties within the study areas. a) LaPerle, b) Thorncliffe, c) Parkview.

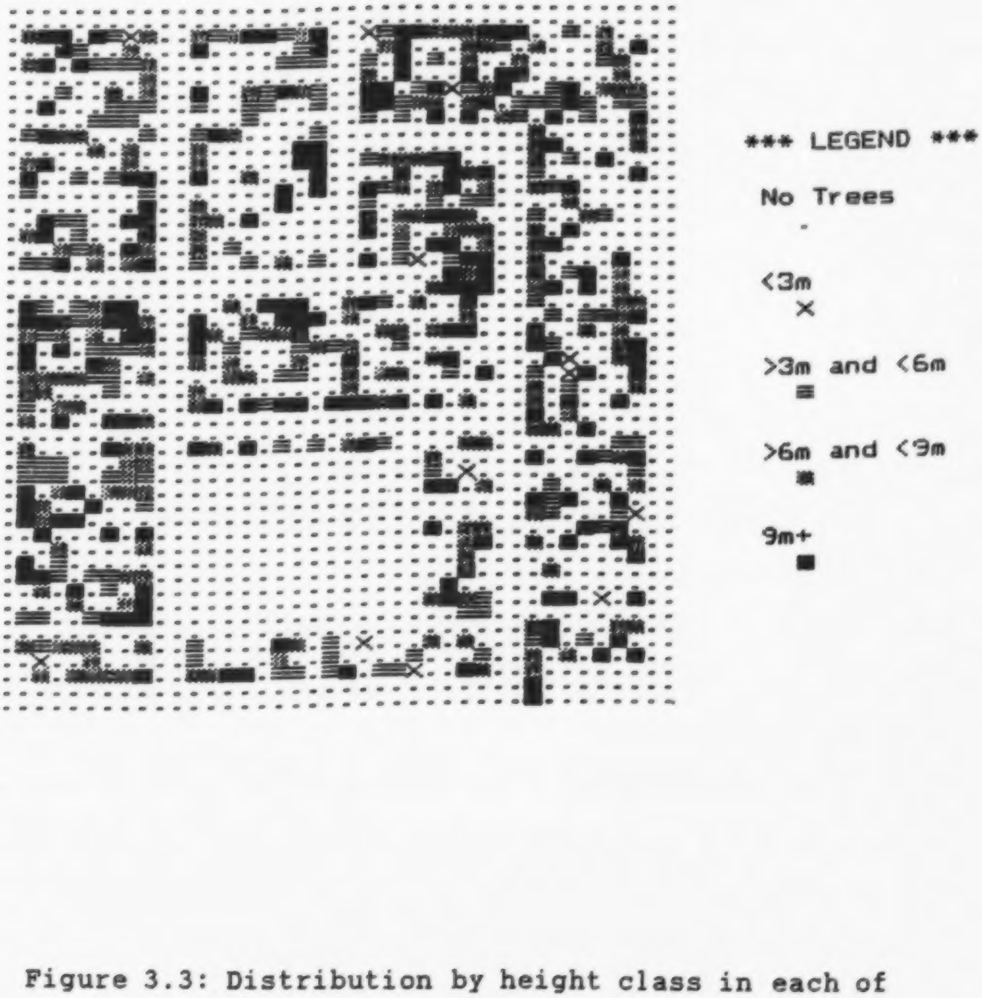

Figure 3.3: Distribution by height class in each of the 10x10m cells within the oldest (35 years) of the study areas, Parkview. North is to the top of the page.

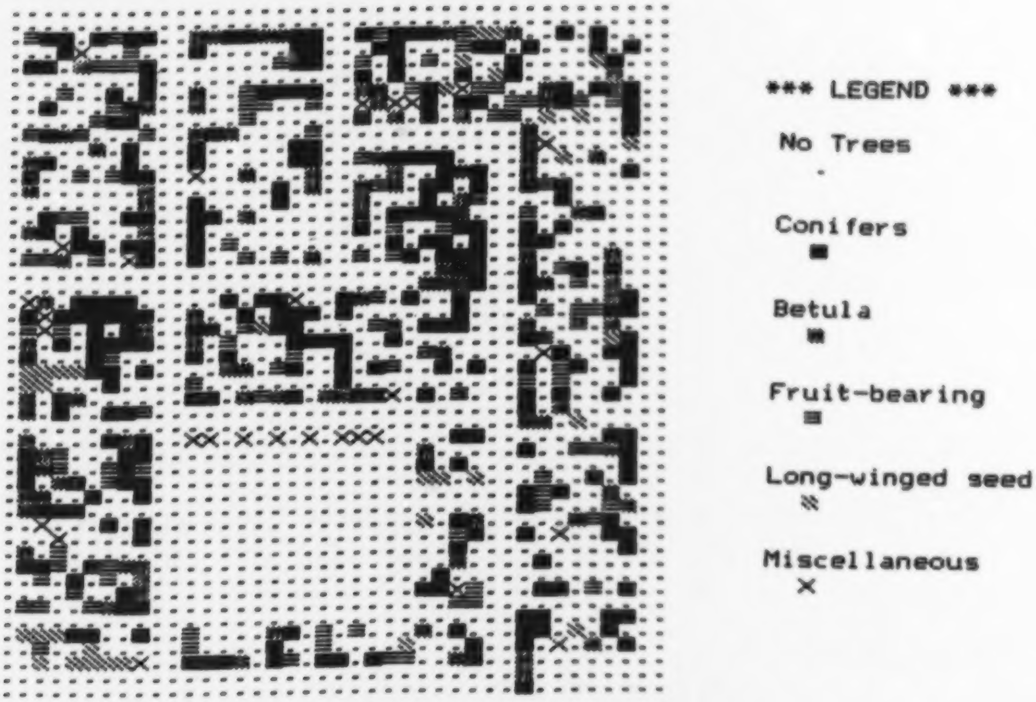

Figure 3.4: Distribution of trees by type within the oldest study area, Parkview. Tree types are shown by mode for each 10x10m cell. North is to the top of the page.

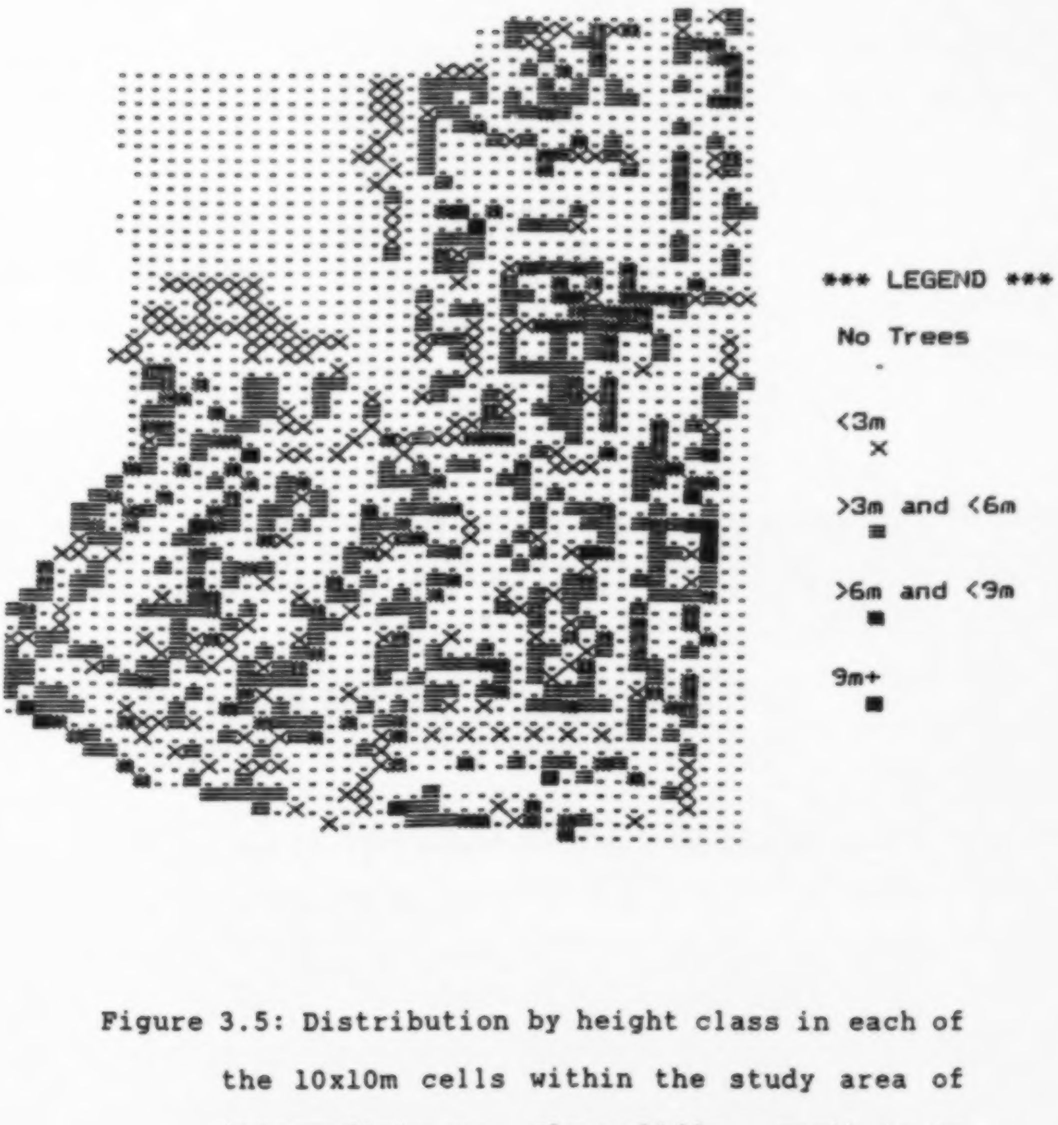

Figure 3.5: Distribution by height class in each of the 10x10m cells within the study area of intermediate age, Thorncliffe. North is to the top of the page.

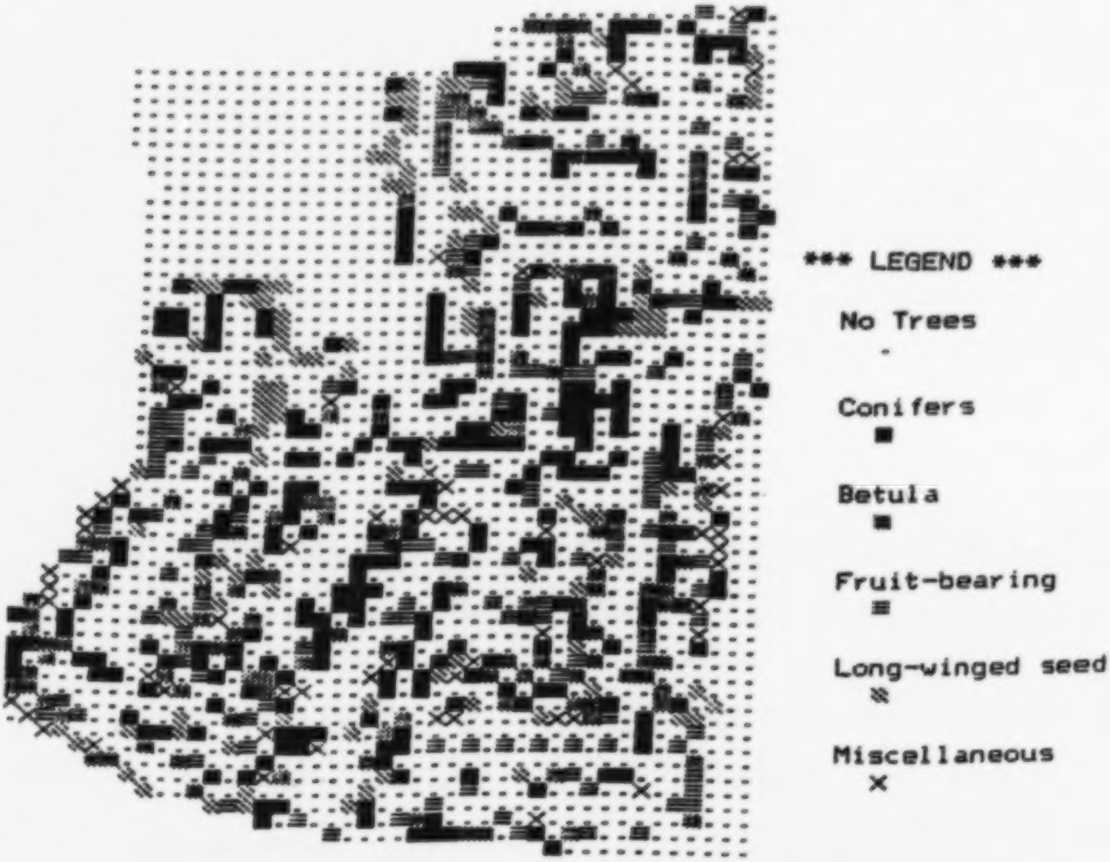

Figure 3.6: Distribution of trees by type within the Thorncliffe study area. The tree types are shown by mode for each 10x10 cell. Classes are fully described in the text. North is to the top of the page.

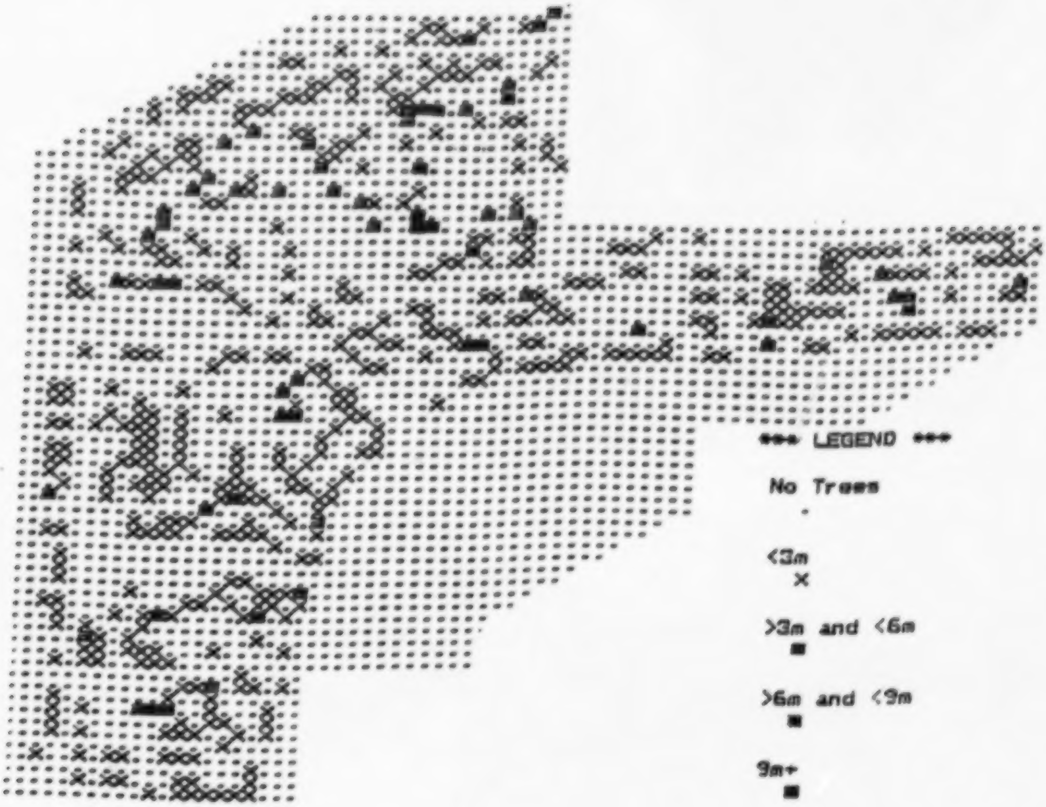

Figure 3.7: Tree distribution within the youngest of the study areas, LaPerle. The distribution of the trees is shown by the height class occurring in each 10x10m cell. North is to the top of the page.

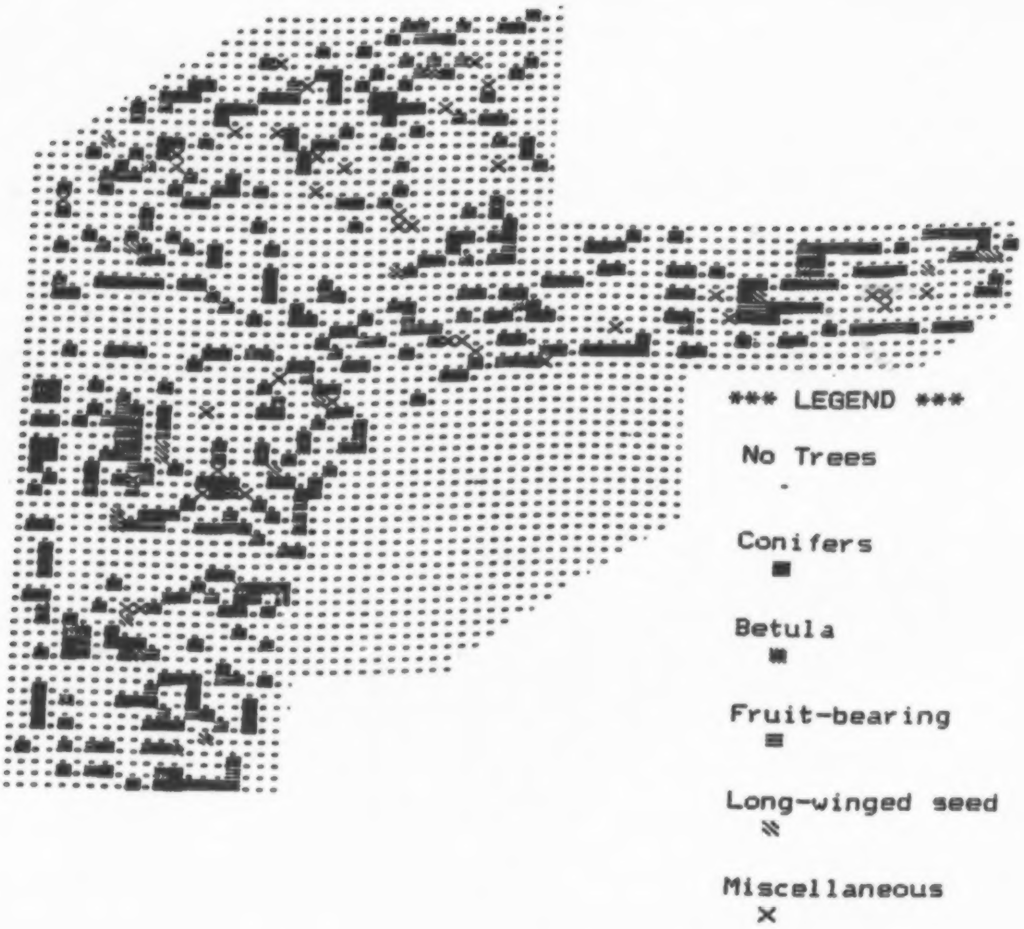

Figure 3.8: Distribution of trees by type within the youngest study area, LaPerle. Tree types are shown by mode for each 10x10m cell. North is to the top of the page.

3.10 Tables

Class	Spruce	Birch	Mtn. Ash	Maple	Apple	Pine	Mayday	Willow	Poplar	Elm	Alder	Oak	Total
1 (<3m)	7	0	6	0	0	0	0	0	0	0	0	0	13
2 (3m-<6m)	67	23	58	12	53	4	11	4	3	1	4	0	240
3 (6m-<9m)	158	54	20	31	11	16	8	7	3	4	0	3	315
4 (9m+)	146	54	0	24	0	8	4	8	6	5	0	0	255
1 (<3m)	1.85%	0.00%	7.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.58%
2 (3m-<6m)	17.72%	17.56%	69.05%	17.91%	82.81%	14.29%	47.83%	21.05%	25.00%	10.00%	100.00%	0.00%	29.16%
3 (6m-<9m)	41.80%	41.22%	23.81%	46.27%	17.19%	57.14%	34.78%	36.84%	25.00%	40.00%	0.00%	100.00%	38.27%
4 (9m+)	38.62%	41.22%	0.00%	35.82%	0.00%	28.57%	17.39%	42.11%	50.00%	50.00%	0.00%	0.00%	30.98%
Total	378	131	84	67	64	28	23	19	12	10	4	3	823
Proportion	45.93%	15.92%	10.21%	8.14%	7.78%	3.40%	2.79%	2.31%	1.46%	1.22%	0.49%	0.36%	100.00%

Table 3.1a:Parkview. Results of the tree cover surveys in the three study areas. See text for description of height classes.

Class	Spruce	Birch	Mtn. Ash	Maple	Apple	Pine	Mayday	Willow	Poplar	Elm	Alder	Oak	Total
1(<3m)	184	21	8	39	12	3	8	1	3	0	0	0	279
2(3m-<6m)	179	109	30	39	20	9	22	6	12	2	0	0	426
3(6m-<9m)	94	22	1	27	0	6	8	8	8	2	0	0	174
4(9m+)	0	0	0	2	0	0	1	1	7	1	0	0	11
1(<3m)	40.26%	13.82%	20.51%	36.45%	37.50%	16.67%	20.51%	6.25%	10.00%	0.00%	0.00%	0.00%	31.35%
2(3m-<6m)	39.17%	71.71%	76.92%	36.45%	62.50%	50.00%	56.41%	37.50%	40.00%	40.00%	0.00%	0.00%	47.87%
3(6m-<9m)	20.57%	14.47%	2.56%	25.23%	0.00%	33.33%	20.51%	50.00%	26.67%	40.00%	0.00%	0.00%	19.55%
4(9m+)	0.00%	0.00%	0.00%	1.87%	0.00%	0.00%	2.56%	6.25%	23.33%	20.00%	0.00%	0.00%	1.24%
Total	457	152	39	107	32	18	39	16	30	5	0	0	890
Dominance	51.35%	17.08%	4.38%	12.02%	3.60%	2.02%	4.38%	1.80%	3.37%	0.56%	0.00%	0.00%	100.00%

Table 3.1b:Thorncliffe.

Class	Spruce	Birch	Mtn. Ash	Maple	Apple	Pine	Mayday	Willow	Poplar	Elm	Alder	Oak	Total
1 (<3m)	170	39	48	25	15	13	15	7	9	1	0	0	342
2 (3m-<6m)	10	11	0	0	0	2	0	3	4	0	0	2	32
3 (6m-<9m)	6	0	0	0	0	0	0	0	11	0	0	0	17
4 (9m+)	0	0	0	0	0	0	0	0	1	2	0	0	3
1 (<3m)	51.99%	11.93%	14.68%	7.65%	4.59%	3.98%	4.59%	2.14%	2.75%	0.31%	0.00%	0.00%	86.80%
2 (3m-<6m)	31.25%	34.38%	0.00%	0.00%	0.00%	6.25%	0.00%	9.38%	12.50%	0.00%	0.00%	6.25%	8.12%
3 (6m-<9m)	35.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	64.71%	0.00%	0.00%	0.00%	4.31%
4 (9m+)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	33.33%	66.67%	0.00%	0.00%	0.76%
Total	186	50	48	25	15	15	15	10	25	3	0	2	394
Proportion	47.21%	12.69%	12.18%	6.35%	3.81%	3.81%	3.81%	2.54%	6.35%	0.76%	0.00%	0.51%	100.00%

Table 3.1c:LaPerle.

Species	Pd	Tm	Cc	Pa	Sp
Breeding	32	3			2
Post-breeding	76		4	1	
Winter	84		2	2	
Total	192	3	6	3	2

Table 3.2: Number of birds/survey associated with fifteen clumps of coniferous trees in the Parkview study area. Data for each season is shown separately: bs-breeding season; pbs-post-breeding season; w-winter season. See Table 2.3 for key to species.

Species	Pd	Tm	Cc	Pa	Sp
Breeding	7	2			3
Post-breeding	61	2	1	1	
Winter	54		1		
Total	122	4	2	1	3

Table 3.3: The average number of birds/survey counted on 10 randomly selected sites within the Parkview study area. See Table 2.3 for key to species.

	Conifers	Birch	Fruit Bearing	Long-winged seed	Misc.
Block I	38	13	11	6	0
Block II	49	15	14	9	2

Table 3.4: Comparison of the vegetation within Block I and Block II of the study area.

	Chipping Sparrow		American Robin		Blue Jay		B-c Chick.	
Block	I	II	I	II	I	II	I	II
Breeding	3	13	18	18				
Post-breeding			2	3	5	14	5	28
Winter					4	15	8	13
Total	3	13	20	21	9	29	13	41

Table 3.5: Birds/ha counted within Block I and Block II of the Parkview study area. Data are given separately for each species in each season.

3.11 References

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4.0 General Discussion and Conclusions

The most striking characteristic of the urban residential environment is the lack of diversity in the avifauna. In contrast to the urban study areas, wildlands support a more diverse assemblage of bird species. The number of species in the Edmonton study areas was lower in all seasons when compared to wildland studies. This disparity in species richness was attributed to a number of factors which exclude many native species-human disturbance, differences in the tree cover, and the close cropped ground cover.

The relative abundance of birds varied with season and study area. The highest density was always associated with the older study area, Parkview, and the lowest density was always associated with the youngest study area, LaPerle. The density of birds during the breeding season was found to be less than the density in wildlands, although some species, such as robins, Chipping Sparrows, and House Sparrows were shown to occur at higher densities in the urban environment. These results were contrary to the findings of other authors, such as Emlen (1974) and Campbell and Dagg (1976), who found that the density of urban birds was higher than the density of birds in non-urban areas. The density of birds in the three study areas was highest during the post-breeding season. No local or regional post-breeding season data were available for comparison. The winter season was the only season in which the density of birds, in any of the study areas, was higher than that in non-urban areas. It was found that the density in the oldest study area, Parkview, was slightly higher than the density of winter birds in aspen forests and sites at similar latitudes. The lower species richness in urban areas was similar to findings of these same authors.

As in almost all other urban bird studies, it was found, in all seasons and all study areas, that the dominant species was the House Sparrow. During the breeding season House Sparrows comprised 63% of the birds in the older Parkview study area and 100% of the bird population in the youngest study area. They comprised up to 100% of the birds seen in the two younger study areas during the winter season and approximately 70% of the bird population in the most mature study area. These results were similar to the findings in other urban studies conducted in widely separated geographic areas such as Arizona (Emlen 1974), Australia (Lenz 1990), and Saskatchewan (Oliphant and McTaggart 1977). Many urban dwellers consider this species to be little more than a pest and some actively and systematically kill them. The House Sparrow is often blamed for the lack of native species in the urban environment, however, there was no evidence in this study which suggests that it was actively excluding native species. Savard (1978) found that the occurrence of this species was negatively correlated with almost all native bird species. The observations in this study are contrary to those findings. In this study, the greatest population density and diversity was associated with the number of House Sparrows. Its wide distribution in all urban habitats suggests that while this species may be a pest, it was also a pioneer species. It survives, albeit in small numbers, in areas where other birds are unable to find sufficient resources for survival.

The surveys of the tree cover within the three study areas showed a remarkable consistency in the types of trees planted by urban landowners. Ten of twelve tree genera occurred in all three study areas with an age span of 35 years. Height was the only significant variable apparent in the tree cover of the three study areas. The oldest area, Parkview, had the tallest trees while the youngest study area, LaPerle, had the smallest trees. The trees in Thorncliffe were of an intermediate height. The difference in height was attributed to senescence. No other case study, which could be compared against the results of this study, could be found in the literature.

Although a number of other studies have investigated some relationships between the urban bird population and features within the urban forest, these works were all limited in their relevance and applicability to the urban environment of Edmonton. Savard (1978) compared bird populations in urban Toronto to the volume of the different layers within the canopy of the urban forest. That study extrapolated tree data from sample plots of 1 or 2 ha to the whole of each study area. While such measurements were sufficient for their intended purpose, they did not for comparative purposes, provide a sufficiently accurate inventory of the tree cover. Weber (1975) who studied the nest sites selected by urban birds in Vancouver estimated the composition of the tree cover in each of three study areas. No studies of the urban forest could found for the prairies of western Canada.

The primary concern, of most urban dwellers, has been with the aesthetic qualities of the urban forest (Hough 1989). From a biological standpoint, habitat is the framework within which ecological and evolutionary processes occur (Wiens and Rotenberry, 1981), yet, in an urban context little has been documented regarding the composition, structure, and diversity of habitats within the urban forest.

In spite of the aforementioned limitations, a number of habitat relationships between the bird population and tree cover were identified. In all seasons, the population density of the birds was statistically related to the number of coniferous trees over 6m in height. Thus, a gradient from the oldest study area in Parkview to the youngest study area LaPerle, was defined. A bird population density gradient followed the gradient defined by the tree height. This gradient was contrary to the findings of an urban bird study conducted in Kitchener-Waterloo by Campbell and Dagg (1976). On their gradient the population density of birds declined from the youngest of their study areas toward the oldest study area. A number of differences in habitat structure existed which may have accounted for this circumstance. The tree density ranged from 0.5 to 0.25 of the tree density found in the Parkview study area and coniferous trees accounted for between 14 and 23% of the tree cover compared to approximately 50% in the Parkview study area. Lastly, their gradient was projected outward from the central business district and did not extend to the urban fringe.

The number of species present in the most mature study area was similar to findings of other urban studies. The number of species in the two younger study areas were less than the number apparent in the mature study area. This difference was most striking in the winter season when 9 species were seen in the mature Parkview study area while only the House Sparrow was found in the younger study areas. By contrast, Spencer (1973) tallied 30 species in two ravine areas which were less than 2 km from the Parkview site.

Several native species, such as waxwings and redpolls have found the urban environment provides access to a major food resource during the winter season. Waxwings were associated with mature Mountain Ash and crabapple trees while redpolls were most often associated with mature birch trees.

Breeding American Robins were associated with the most mature study area which had the largest number of coniferous and birch trees in excess of 9m in height. The breeding density in this area was approximately triple the density in the younger Thorncliffe area. The higher breeding densities resulted in smaller average territories in the Parkview study area, although the difference was not statistically significant. The density of breeding robins in the Parkview study area was more than double the density of breeding robins in wildlands, while the breeding density of robins in the Thorncliffe area was nearly equal to the breeding density in some wildlands (Emlen 1984). Robins migrating through the urban environment were more common in the older Parkview study area. This was attributed to their preference for areas which were structurally similar to the preferred breeding areas. Similar preferences have been noted in the migrating behaviour of parulids (Parnell 1969).

The density of breeding Chipping Sparrows in the urban environment was higher than the breeding density found in wildland studies (Yahner 1986; Bock and Lynch 1970). Although the average size of breeding territories in Thorncliffe were larger than those in Parkview, the difference was not statistically significant. In the breeding season, a statistical association was found between the number of breeding territories and the number of birch and coniferous trees between 6 and 9m in height. During the fall migration, Chipping Sparrows showed a preference for the middle-aged study area of Thorncliffe. This preference was associated with the number of coniferous trees between 3 and 6m in height. Thus it was concluded that Chipping Sparrows had somewhat different habitat preferences in the two seasons.

In conclusion, although the population density and species richness were described and compared for the three study areas, there was a lack of data for urban areas with structurally similar environments. As a consequence, the principal role of this study is in the form of baseline data for further investigations into the ecology of urban birds.

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